DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT OF THE

FOREST PRODUCTS RESEARCH BOARD

With the Report of the Director of Forest Products Research

FOR THE YEAR 1930

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REPORT OF THE FOREST PRODUCTS RESEARCH BOARD FOR THE YEAR 1930

To the Lords of the Committee of the Privy Council for Scientific and Industrial Research

MAY IT PLEASE YOUR LORDSHIPS,

WE, the Forest Products Research Board, beg leave to present our report for the year 1930.

GENERAL

1. Progress has been well maintained. Requests on the part of the wood-using professions and trades for the services of the Forest Products Research Laboratory have been increasingly heavy in all departments, and there is every evidence that the work is bearing fruit.

CONSTITUTION OF THE BOARD

2. We have to record the retirement from the Board of Professor Sir John Farmer, D.Sc., F.R.S., and of Lieut.-Colonel Sir David Prain, C.M.G., C.I.E., F.R.S. Sir John Farmer was the first Chairman of the Board and Sir David Prain the first Director of Research. The wise guidance and help of these gentlemen during the difficult years of the inception of the work were invaluable, and it is a matter of great regret to us that we no longer have their services. We welcome the appointment to the Board of Professor V. H. Blackman, Sc.D., F.R.S., Professor of Plant Physiology and Director of the Biological Laboratories, Imperial College, recently also a member of your Lordships' Advisory Council, of Sir Arthur W. Hill, K.C.M.G., F.L.S., F.R.S., Director of the Royal Botanic Gardens, Kew, and of Sir Clement D. M. Hindley, K.C.I.E., M.A., M.Inst.C.E., late Chief Commissioner of Railways, Railway Board, India, a member of the Council of the Institute of Civil Engineers, and Chairman of the Steel Structures Committee of the Department. One change has taken place in the official representation, Sir John Stirling Maxwell, Bart., K.T., T.D., who has succeeded Lord Clinton, P.C., D.L., J.P., as Chairman of the Forestry Commission, having taken Lord Clinton's place on the Board.

CENTRALIZATION OF THE OUTLYING SECTIONS

3. Removal of the Sections of Wood Structure and Chemistry from Oxford and of Mycology from London into their new quarters at Princes Risborough is now complete. This centralization has already proved of great benefit to the speed and economy of the work, especially in relation to the considerable number of inquiries and visits relating to Empire timbers. Your Lordships will recall that it was a condition of accepting the work for the oversea Empire that the building extension should be sufficient for this centralization. The proviso has been amply justified. We would here express our

appreciation of the assistance rendered to us by the Imperial College of Science and Technology, London, the Imperial Forestry Institute, Oxford, and the Department of Chemistry, Oxford University, during the past years. In particular our thanks are due to Professor Percy Groom, M.B.E., D.Sc., F.L.S., F.R.S., who supervised our Section of Mycology at the Imperial College, to Dr. L. Chalk, M.A., who took charge of the Section of Wood Structure during the initial period of its existence at Oxford, and to Professor F. Soddy, M.A., F.R.S., in whose laboratory our Section of Chemistry was housed. The liaison thus formed with these organizations has been of great benefit and it will be our care to maintain it.

Section of Physics

4. The end of the year covered by this report has seen the establishment of a separate Section of Physics, under the charge of Mr. W. W. Barkas, M.Sc. The scope for physical investigation has become very evident in the work of all the previously established sections of the Laboratory. The study of the processes of moisture movement, for example, is of importance not only in seasoning where drying rates must be carefully controlled but also to the entomologist and mycologist, since the susceptibility of wood to attack by insects or fungi is largely influenced by the conditions of moisture and temperature prevailing. The penetration of gases (e.g., air) into wood and the replacement of moisture by gas, and *vice versa*, also require investigation by the physicist. Though attempts have been made to explain, in terms of capillary action, the way in which water is held in wood below the fibre-saturation point, the results have not been very successful and it seems probable that adsorption of water by the wood substance itself is also involved in order to account for the decreased vapour pressure of the water held in wood. In fact, it seems evident that the colloidal nature of wood substance is of importance in explaining many of the properties of wood in bulk. Instances of this may be found in the " collapse " of wood during seasoning and its subsequent reconditioning, in the plasticity of wood at high degrees of temperature and moisture content, in the volumetric changes accompanying dehydration below the fibre saturation point, and in the hysteresis cycles found in moisture equilibrium conditions.

The Development of Entomological work

5. The development of the Section of Entomology during the past five years has shown that, in general, the work involved can be considered under the following three headings :—

(1) *Field Work*, consisting chiefly of surveys of the conditions with regard to insect damage to timber in the different branches of the timber trade, and including the collection of material required for experimental work in the Laboratory. This field work enables the Section to keep in close touch with the timber trade and using industries and to ascertain the insect problems with which they have to deal.

(2) *Research Work*, consisting mainly of biological studies of the insects concerned and undertaken as a result of the field investigations mentioned above. Biological work frequently requires the co-operation of other sections of the Laboratory (e.g., Mycology, Chemistry, Physics and Seasoning) and leads to the development of methods of prevention and control of insect

damage to timber. The standard testing of wood preservatives in insecticides is also included under this heading.

(3) *Advisory Work*, in which information and advice are given to indicate how the results of the research work may best be applied.

Revision of Existing Specifications for Building Timber

6. We would call special attention to an important matter raised by the Director of Research in his report (p. 16) of the conferences that are in progress between various bodies interested in the revision of existing specifications for building timber. It is common knowledge that one of the chief factors in the satisfactory behaviour of timber in service is that it should be " properly seasoned," particularly in view of the modern practice of steam heating whereby buildings are kept drier and warmer than in the past. Hitherto, the general method of seasoning sawn timber has been to stack it in open piles in the yard or shed for some considerable time before bringing it into use, the periods of storage varying with the dimensions and species of timber as found by experience to be necessary. Generally no determination of the precise percentage of moisture in the timber is made at the end of the seasoning period, the degree of dryness often being judged by such vague methods as touch, appearance, weight, or assessed on the basis of the duration of the seasoning process. Consequent upon this custom, the degree of seasoning laid down in a specification is commonly expressed as a function of the seasoning period, by prescribing the minimum time during which the timber shall have been stored for seasoning. With the variables introduced by the time of year at which seasoning is begun or the timber brought into use, local climatic conditions, the variation of conditions from the normal, the initial moisture state of the timber, its dimensions, and the varying manner in which it may be piled and protected, it is obvious that the expression of the degree of seasoning in this way cannot have the precision necessary under many conditions. This practice opens the way to the use of timber insufficiently seasoned for its intended purpose. It would, for instance, rarely be possible in this climate under ordinary conditions of air-seasoning to bring the moisture content of block and strip flooring down to the 10 per cent. that would be necessary for use in a steam-heated room ; a supplementary conditioning treatment would be necessary, either in a warmed store or a kiln. The only sure method of drawing up a specification—of which precision is the essence—for degree of seasoning is to name the moisture content required. " Properly seasoned " is a relative term. As the Director's report shows, different degrees of seasoning are required for different purposes, from a moisture content of 20 per cent. prior to creosoting, or when the timber is not exposed to very dry conditions, down to 9 per cent. for high-class work under severe conditions of steam heating. The specification of the degree of seasoning in terms of moisture content is fast becoming the general practice in Canada and the United States. The method of determining the moisture content is a simple and practical operation.

Co-operation with the Food Investigation Board in the Study of the Fish-Curing properties of Wood Smoke

7. The time-old processes of the smoke-curing of fish have hitherto always been in the hands of practical men, and it is generally recognised that their ends have been attained by purely empirical means. From time to time it has become apparent that

in the absence of definite methods of selection of wood and in the production therefrom of smoke of uniform quality, much has been left to be desired in the matter of the uniformity of the commercial products. In the Director's report an account is given of the preliminary efforts made by the Section of Chemistry, in co-operation with the Torry Research Station, Aberdeen, to obtain more accurate information than has hitherto been available about the actual constituents of wood smoke which effect the "cure" and impart to the finished product its varous characteristics such as colour, sheen, odour and taste. The aim of the investigation is to evolve some simple means of control which can be applied to obtain the most effective smoke with definite curing properties.

Work for the Empire Oversea

8. It is with great satisfaction that we draw attention to the volume and speedy progress of the work, described in the concluding section of the Director's report (p. 36), carried out under the auspices of the Empire Timbers Committee on behalf of the Empire oversea. The year under review is the first year of the operation of these new arrangements, inaugurated by your Lordships at the close of 1929 and fully described in our report for that period, and it was not until the close of the present year that full facilities at the Laboratory became available. The progress is therefore the more gratifying and promises well for the future. The increase of general public interest in Empire timbers and of the use of such timbers, not only in Government but also in public and private buildings, has been particularly evident during the past year, and is testimony to the joint work of the Empire Marketing Board and this Department. Favourable as these results are, however, we would again stress the point that this joint work is not by itself sufficient to cover the necessities of the situation in achieving a general development and national use of Empire timbers. The effectiveness of our work will be impaired unless adequate machinery exists to deal with production and marketing as well as with research, and unless these three phases are closely co-ordinated. Apart from measures to be taken by the timber trade to develop more extensive commercial dealings in Empire timbers, there is a lack of adequate official machinery for dealing with difficulties in the producing areas and concerning production generally, more especially in certain of the tropical regions. These difficulties could be largely overcome by comprehensive botanical and economic surveys of our forest resources, involving some enlargement of the facilities at the disposal of the Imperial Forestry Institute and the Forest Services, and by closer liaison and personal touch with the interests concerned in the country of origin. These matters are being discussed with the appropriate authorities.

J. C. IRVINE,
(Chairman).

April, 1931.

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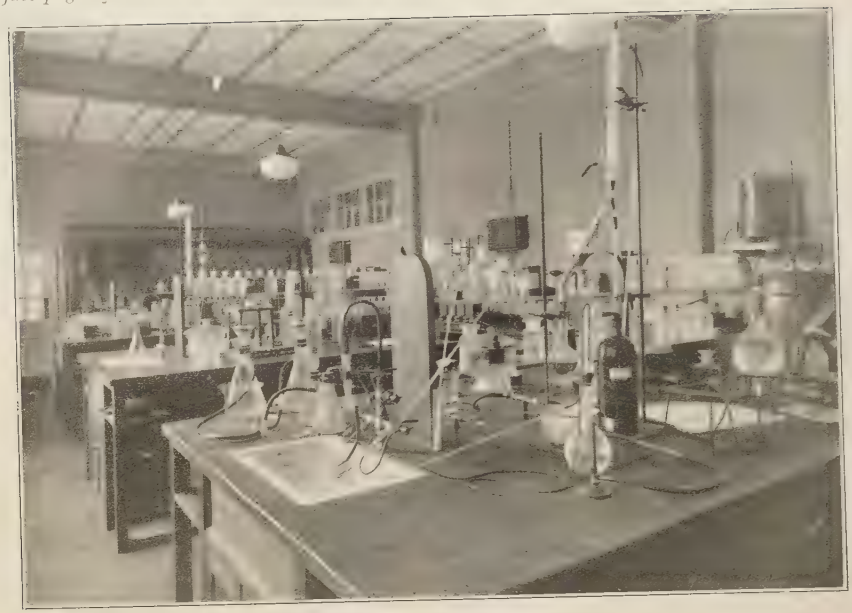


(*A*) The Chemical Laboratory.

(*B*) The Wood Structure Laboratory.

FIG. 1.—*Photographs of the New Buildings.*

REPORT OF THE DIRECTOR OF FOREST PRODUCTS RESEARCH FOR THE YEAR 1930

I.—INTRODUCTION

A review of the work of the Forest Products Research Laboratory for the year 1930 shows that progress has been well maintained, both in the volume of work carried out and in the results achieved. Calls on the part of all sections of the wood-using professions and trades continue to increase. A marked feature of this increase has been the number of inquiries addressed to the Laboratory as a result of the work of the Empire Marketing Board in promoting the more extended use of Empire timbers, of both home and oversea origin, in the various building operations throughout the United Kingdom.

The new buildings for Empire work and for the accommodation of the outlying Sections of Wood Structure (formerly designated Wood Technology), Chemistry, and Mycology from Oxford and London were virtually complete at the end of the year. The benefit of increased facilities for Empire work will be more evident during the coming year. The benefit of centralizing the outlying Sections was immediate, for, as stated in the last Report, the services of these Sections are in daily demand both for consultation with the other Sections and to deal with inquiries, and the unavoidable break in the work caused by removal to the new quarters at Princes Risborough has been more than counter-balanced by the advantages of this closer contact. Photographs of the new Chemical and Wood Structure Laboratories are given in Fig. 1.

On the 31st December, 1930, the staff of the Laboratory numbered 156, made up of : Scientific and Technical staff, 50 ; Laboratory Assistants, boys and girls, 20 ; Office staff, 15 ; Foremen and Industrial Staff (including messengers and charwomen), 71. A list of Scientific and Technical staff is given in Appendix I.

II.—THE PROGRAMME OF RESEARCH

(*United Kingdom Division*)

Studies in Wood Structure : *Improvement in Technique*

In previous reports reference has been made to studies of the microscopic structure of wood, in relation to its technical properties. These studies, being largely comparative, are to a considerable extent based on measurements, sometimes amounting to thousands in the course of a single investigation, so that, while accuracy is the first essential, speed is a desirable feature in any method employed. The method of projecting the image of an object on to a screen combines the advantages of a high degree of magnification, a large field of view and a minimum of eye-strain. By moving the measuring scale relative to the image, instead of repeatedly moving the object as in the ordinary method of making miscroscopic measurements, simple measuring operations can be

carried out with a very considerable saving of time and without loss of accuracy. The method is capable of wide application to studies which involve observations on relatively gross anatomical features, such as pore-size, fibre-length, or the proportions in which the various wood elements are present.[1]* It does not, of course, take the place of direct microscopic examination in observations on the finer details of wood structure, where the use of high magnification is only of value when it is combined with the highest degree of optical resolution obtainable.

[1] The Use of the Projection Apparatus in Anatomical Studies of Timbers. *Forestry*, 1930, **4** (1), 40–44.

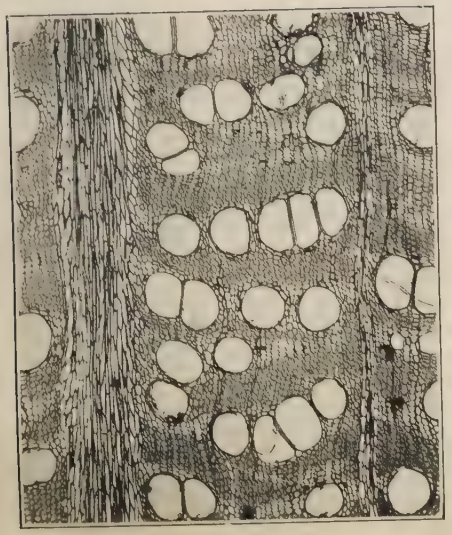
The Shrinkage of Wood

In continuing the study of shrinkage, microscopic examination by the Section of Wood Structure has been applied to an investigation of the primary factors underlying one of the outstanding peculiarities of the wood, namely, the difference between linear movement in the radial and tangential directions. This difference is partly explained by the variation in the type and arrangement of the individual wood elements and tissues. It has been generally accepted that wood rays exercise a restraining influence on radial shrinkage; moreover, the occurrence in many woods of tangential bands of dense tissue alternating with bands of lighter and more porous tissue, is supposed to be partly responsible for the small shrinkage in the radial direction. In order to examine the truth of these general statements and to extend our knowledge of the principles of shrinkage, observations have been carried out on a series of woods selected to cover a wide range of structure.[1]

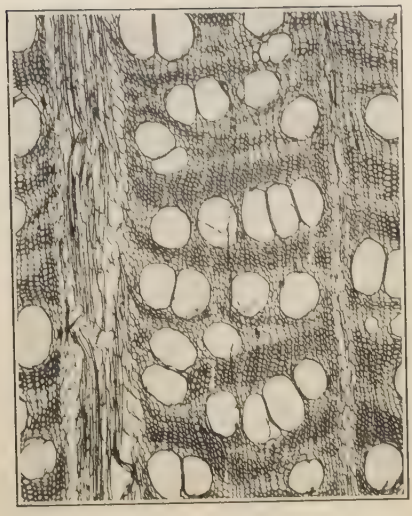
The overall shrinkage of a block of wood was found to be the resultant of the several different types of behaviour shown by the individual elements or groups of elements. When the behaviour of the different elements was examined separately, it was found that the fibre groups, for instance, appeared to shrink regularly in both the tangential and radial directions; the rays, being composed for the most part of cells with their long axes in the radial direction, showed a low radial and a high tangential shrinkage, while changes in the dimensions of the thin-walled vessels and wood parenchyma were largely controlled by the behaviour of the fibres and rays. Comparison of a number of woods characterised by large rays showed that the high ratio, tangential shrinkage radial shrinkage, was frequently due to a high tangential rather than a low radial shrinkage.

The change in structure that accompanies shrinkage is illustrated in Fig. 2, which consists of photomicrographs of thin cross sections of wood in the saturated and oven-dried conditions. The species selected, Southern Silky oak (*Grevillea robusta* A. Cunn.), has large wood rays and also tangential bands of vessels and parenchyma alternating with zones of dense, thick-walled fibres. The two photomicrographs in each pair show precisely the same area of wood, and are intended to illustrate the effect of shrinkage on the various wood elements. The change in the overall dimensions can also be seen. Comparison of Sections A and B shows the decrease in the radial width of the bands of fibres due to shrinkage, and the accompanying distortion of the vessels and ray cells. Sections C and D, at a higher magnification, show the change in the fibre wall thickness and the distortion of a vessel and the thin-walled parenchyma, due to the regular shrinkage of the fibre groups.

* These numbers relate to the references at the end of each section.



A



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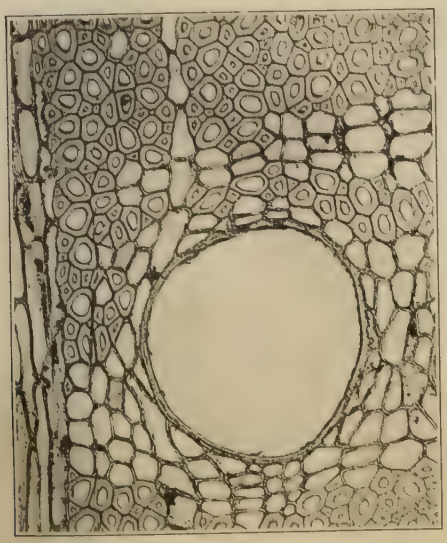

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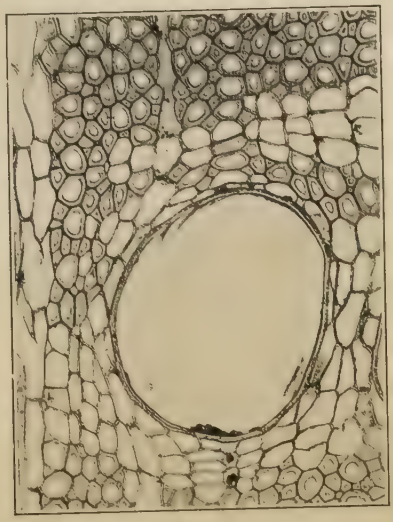


D

FIG. 2. *Transverse sections of Southern silky oak (Grevillea robusta). (Magnification A and B* × 25. *C and D,* × 130), *illustrating the shrinkage of wood. A and C. Sections in saturated condition. B and D. The same in oven dry condition.*

It is noteworthy that, in the sixty species of wood examined in the course of this investigation, radial shrinkage most nearly approached tangential in the case of mahogany. It should be pointed out, however, that the original selection of species was made so as to cover as wide a range of structure as possible. More particular attention is now being given to the anatomical features associated with small differences between radial and tangential shrinkage.

As part of the same general study of shrinkage, the movement of timber due to temperature rather than moisture content changes is being studied by the Section of Seasoning. A method of measuring thermal expansion and contraction has been devised and some observations on the movement of oven-dried and of the green samples have already been made. There is a difficulty yet to be overcome in measuring the thermal expansion at a fixed moisture content lying between oven-dry and fibre saturation point, for under the temperature changes necessitated by the experiment the moisture content is apt to vary somewhat and from this cause dimensional changes consequently occur. An interesting result in the case of green timber showed that the effect of increasing temperature was to cause contraction in the radial direction. This confirmed earlier observations on similar movements in timber.

Some experiments in shrinkage of a more practical nature are concerned with the effect on the working or movement of timber coated or impregnated with various substances. These are still in progress.

In connexion with shrinkage, the reader is referred to the description, on page 42, of experiments in connexion with a defect known as "collapse," which resembles excessive shrinkage but is due to a different cause.

(1) CLARKE, S. H. The Differential Shrinkage of Wood. *Forestry*, 1930, **4** (2), 93–104.

The Relations between the Moisture Content of Wood and the Surrounding Hygrometric Conditions

The practical investigation of the previous two years into the seasonal variation of moisture content in furniture woods has been carried further by a laboratory study of the equilibrium values of the moisture content in wood that correspond with different temperature and humidity conditions of the surrounding air.

It was found that, for any hygrometric condition, the value of the equilibrium content differed considerably among the species tested. It was also noticed, over the range of humidity studied, that if a sample was completely dried in stages and rewetted, there was a marked hysteresis effect, the value of the moisture content for any particular temperature and humidity condition being appreciably lower on the rewetting than on the drying cycle. Unfortunately, difficulty was found in making reliable observations at the higher humidities, and this problem is receiving further consideration.

The Dry Weight of Wood and Moisture Content Determination

The most generally used method of determining the moisture content of wood is that of drying a representative sample in a ventilated oven at a temperature of 100°–104° Centigrade until it ceases to lose weight. The moisture content value is based on the final dry weight of the sample, and depends therefore on the accuracy with which

that weight is determined. Some tests have been made to find what variations in the so-called dry weight occur in the normal routine of moisture determination and to see how these are influenced by small deviations from the routine procedure. The air entering the oven from the room in which it is kept is not dry. The air in the oven therefore will always contain moisture, varying in amount with the hygrometric conditions of the surroundings. The attached curves of Fig. 3 show a record of the temperature and humidity of the air in a laboratory during a period when observations were made. A third curve indicates what would be the humidity of the entering air when raised to the temperature of the ovens. The fourth curve records the actual variation in the weight of a dried sample kept in the ovens. It will be seen that this weight curve closely reflects the variations in humidity of the ventilating air. The so-called dry weight is not constant, therefore, and is not a true dry weight. It was found in the experiments that the dry weight obtained at 100° C. in dry air was about 0·5 per cent. lower than that obtained at the same temperature in an oven fed from ordinary atmospheric air. A fluctuation of $\pm$ 0·2 per cent. occurred in the latter dry weight due to external hygrometric conditions.

The whole work has made it clear, however, that though the usual oven-drying method of determining moisture content is far from exact in a strict sense, it allows of considerable latitude in operation before the errors introduced exceed the tolerance permissible in everyday practice.

The problem of moisture determination was extended to embrace other methods which not only might have the advantage of speed of operation, but also an especial usefulness in the case of timbers which contained unusual amounts of gums, resins or other volatile substances. The method of distillation in xylol, for instance, showed results in striking contrast to those of oven-drying in the case of samples of Apitong (*Dipterocarpus grandiflorus* Blanco), and a very resinous pitch pine.

In the case of oven-drying, a certain amount of volatile matter may be evaporated as well as the water, and the loss in weight during drying would include both these items, while the " dry weight " would represent not only wood substance, but also the remaining extractives which are non-volatile below 100° C. The xylol method differs from this in that only the water portion of the distillate is measured (the oils being dissolved in the xylol), while the " dry weight " of the wood as a whole is estimated by subtracting the weight of water from the original weight of the sample.

In an attempt to obtain an expression for moisture content as a percentage of the dry weight of wood substance the following modification of the standard xylol method was introduced. After the usual distillation the xylol extract was removed and the dry weight of the wood residue was determined by oven-drying at 100°–104° C. Thus, although all the extractives could not be removed from the wood by this means, the dry weight obtained was a closer approximation of the dry weight of wood substance than that obtained previously. It is conceivable that if an acceptable modification such as the above could be applied in practice, woods which contain a high percentage of xylol-soluble extractives could be brought more into line with woods low in xylol-soluble constituents than has hitherto been possible. The results obtained on two samples of timber under test are shown on the opposite page.

Another means of moisture determination tested during the year was an apparatus marketed as a commercial instrument, depending on the variation with moisture content of the electrical resistance of wood. Two needle contacts fastened into a handle are pressed into the timber under test, and the reading can be made almost instantaneously. This method has a great advantage over others in that it is very quick, and it does not

necessitate the cutting or destruction of the wood as does the oven-drying and similar methods. The instrument has limitations, chiefly due to the irregular manner in which moisture is generally distributed in timber in practice and to the large influences that surface tension or impurities exert on the electrical conductivity of any sample, and it cannot be regarded as one of great precision. Nevertheless, from a practical point of view, the instrument has an undoubted usefulness, which can be increased by experience in the hands of an intelligent operator.

MOISTURE CONTENT DETERMINATION OF TIMBER CONTAINING RESINOUS MATERIAL

KEY

W = Weight of wood substance
M = Weight of moisture
R = Weight of resins, oils or gums
$(W + M + R)$ = Wet weight of samples.

Method.	Basis of Determination.	Apitong.	Pitch Pine.
		Per cent.	Per cent.
Xylol distillation	$\frac{M}{(W + M + R) - M} = \frac{M}{W + R}$	11·3	8·3
Xylol distillation for determination of water. Wood substance obtained by dissolving the resins by refluxing, and drying the wood in an oven afterwards.	$\frac{M}{W + kR}$ where k = fraction of resins not dissolved.	13·7	13·3
Oven-drying, applying the formulæ :— $\frac{\text{Wet Wt.} - \text{Dry Wt.}}{\text{Dry Wt.}}$	$\frac{(W + M + R) - (W + k'R)}{W + k'R} = \frac{M + (1 - k')R}{W + k'R}$ k' = fraction of resins remaining.	19·8	15·8

Perhaps the chief advantage of a rapid and direct means of moisture determination would lie in the greater possibility, in commercial work, of expressing the degree of seasoning of timber in terms of moisture content, especially in connexion with the clauses dealing with degree of seasoning in contract specifications. There is urgent need to modernize these specifications by stating the actual moisture content, or a range of moisture content, that will be permitted, rather than prescribing the length of the period of seasoning. This question is examined in more detail in the section of this report, on page 16, dealing with specifications.

Kiln-seasoning Properties of the Commoner Home-grown Timbers

The study of the kiln-seasoning properties of the commoner home-grown timbers has been continued steadily and kiln experiments on the large scale have been made,

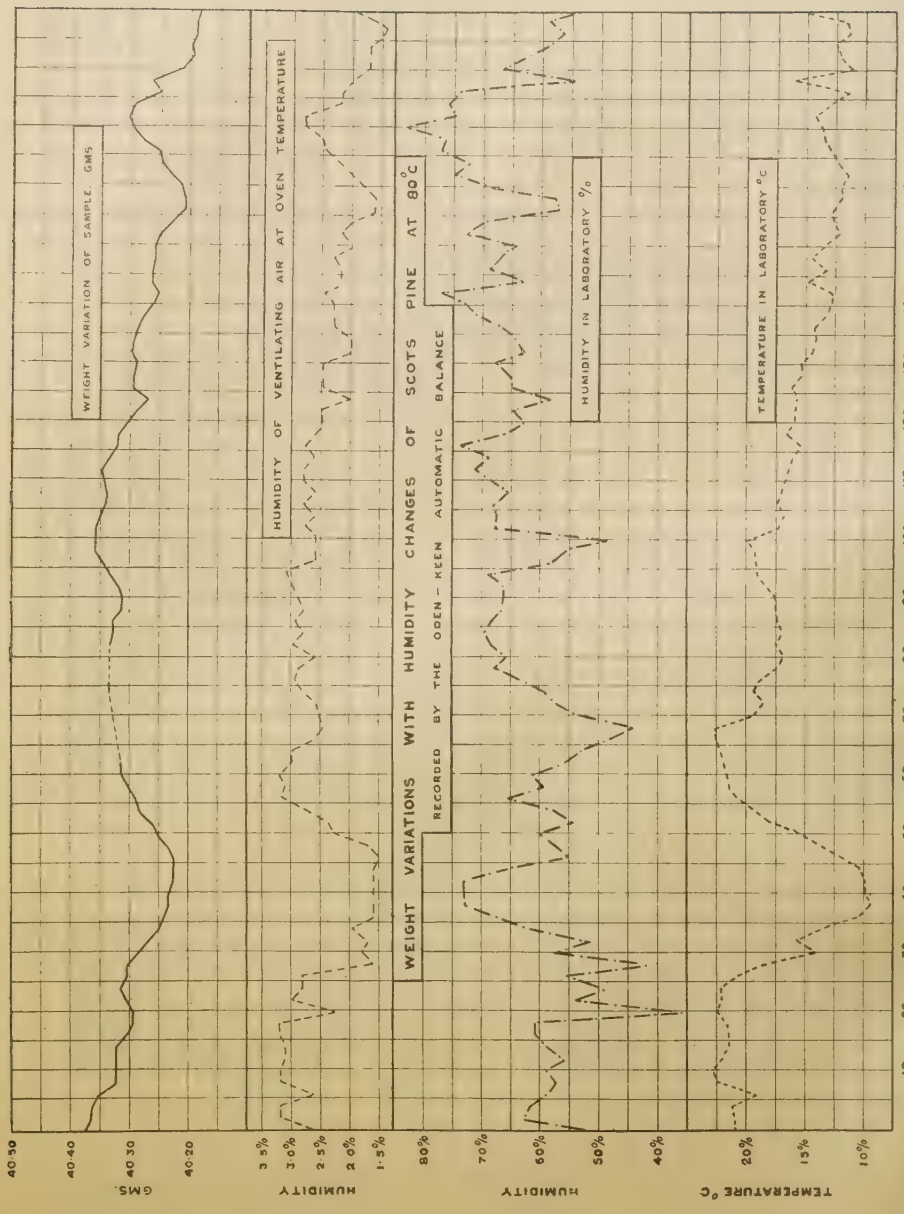

WEIGHT VARIATION OF SAMPLE. GMS
HUMIDITY OF VENTILATING AIR AT OVEN TEMPERATURE
WEIGHT VARIATIONS WITH HUMIDITY CHANGES OF SCOTS PINE AT 80°C
RECORDED BY THE ODEN - KEEN AUTOMATIC BALANCE
HUMIDITY IN LABORATORY %
TEMPERATURE IN LABORATORY °C
GMS.
HUMIDITY
HUMIDITY
TEMPERATURE °C
TIME IN HOURS
DEC 1929

FIG. 3. *Variations in weight of a "dry" sample in an oven with those of the humidity of the ventilating air.*

using oak, poplar, Dutch and Wych elm (*Ulmus major* Sm. and *U. montana* Stokes), Corsican pine, Silver fir and Douglas fir.

An important outcome of the work has been the conclusion that in thicknesses much greater than one inch it is not in general likely to be an economic proposition to kiln-season English oak from the green without a preliminary period of air-seasoning. From a technical point of view the operation is quite possible, and a load of $1\frac{5}{16}$ inch thick flooring strips was dried during the year in a highly successful manner. In commercial work, however, the time required for successful drying is likely to be considered too long in the case of greater thicknesses.

An interesting experiment on sycamore, made in a small kiln, indicated that the darkening of colour, which has been found to occur in kiln-drying and which is a serious defect in a timber so generally valued for its whiteness, is influenced by the temperatures used. With a temperature not exceeding 115° Fahr. the timber remained as white as when air-seasoned under cover.

The elms still present a difficulty due to their tendency to warp and collapse, but it is hoped that some improvement may be effected by means of a reconditioning process which is described in detail on page 42 of the section dealing with work for the Empire overseas.

A change has been made in the method of conversion of hardwoods for the large scale routine kiln experiments. Instead of simply sawing through and through to a standard thickness, a variation in the manner and dimensions of conversion is now allowed, so that the timber can be converted to some commercial size for which its quality fits it. The object is the elimination of large growth defects, which, if left in the timber, have a preponderating influence on the final quality after drying and thus prevent the true assessment of the inherent aptitude of the species for kiln-drying.

Modifications and Extensions to Kilns and Plant

Whenever possible during the experiments on kiln-seasoning, investigation is made of the variations in temperature and humidity and of the distribution of air circulation in the kiln-chamber. This frequently leads to modification of the design with a view to improvement. An example is the inlet duct of the external fan kiln, which has been rebuilt in order to improve the air circulation.

Further work has been carried out on the natural draught type of kiln and a second chamber has been completed to give further scope in the investigation of the type, which is chiefly of use for completing the drying of timbers already partly seasoned. The circulation in these kilns is dependent on temperature differences existing in the chamber, and consequently, unless the building is very well insulated, air movement is influenced by external weather conditions. Consideration is being given to means whereby this difficulty can be overcome.

During the year a new kiln has been added, which is to be fitted so that it can be used alternatively as an external or as an internal fan kiln ; in each case the air will circulate downwards from above, in contrast to the arrangement of the existing kilns of these types.

A new pilot kiln has also been built and another is in construction. These small model kilns, which are never out of use, are invaluable not only for kiln experiments preliminary to full-scale test, but also for the preparation of material for the work of other sections of the Laboratory, and for more fundamental investigation into the principles of seasoning. They have been in frequent use during the year for preliminary tests of the seasoning properties of a number of Empire timbers.

A further addition to the plant of the Section is a chamber in which a constant temperature of about 70° Fahr. and a constant humidity of 55 per cent. will be maintained. This is intended to complete the air-seasoning of samples prepared by the Section of Timber Mechanics, and bring their moisture content to 12 per cent., the standard fixed for test. Hitherto it has been found that the samples, even when stored in the most favourable positions, only attained the desired condition during short periods of favourable weather.

Air-seasoning

The details of a scheme of work which is to be undertaken in co-operation with the Forestry Commission, representing the beginning of a systematic investigation of the process of air-seasoning, have been fixed and it is hoped that work will commence during the coming year.

A number of piles of timber have, however, been erected and studied during the period under review, whenever timber became available. The material used was generally that needed for the work of other sections of the Laboratory, the nature of whose requirements or their urgency did not permit of air-seasoning to a sufficiently low final moisture content to allow of a full comparison with the kiln-seasoning tests of the same species.

Nevertheless some useful information on the manner of drying of certain species was obtained, as well as data connected with end-splitting. It was proved, for instance, that this defect can be materially reduced by painting the end of the boards with a moisture-resistant coating. It was also noticed that if slightly wider piling sticks were used at the ends of the pile and placed so as to overhang the ends by an inch or so, the shelter afforded appeared to reduce end-splitting, but further observation is desirable on this point. On the other hand piling sticks placed flush with the end of the boards seemed to be no more effective than when laid a few inches within the pile.

Steam Bending

A laboratory has now been constructed and is being equipped for the purpose of studying the process of steam bending. In taking up this work, there is more than one object in view. Primarily it is desired to make a technical investigation into the operation of bending, and to determine the influence of the many variables concerned. From this, as a secondary work, it is hoped that tests may be developed by which the value of Empire-grown timbers for bending work may be quickly and reliably appraised, with the object of finding uses for the more suitable of them where our supply of home-grown material is falling off. A preliminary scheme of experimental work has been drawn up and will be put into operation in the early part of next year.

Influence of Kiln-seasoning upon Mechanical Properties of Timber

Tests to determine the effect of kiln-seasoning upon the mechanical properties of timber were carried out during the year on material representing 14 kiln runs. In these tests control samples are tested green and air-dry and similar test pieces are taken from the material treated in the kiln. The green material was tested as received in each case and the kiln-dried material was tested as soon as it was released after the Seasoning Section had completed its observations. The air-dry material in each case must remain in storage until the moisture content has dropped to the standard of comparison, 12 per

cent., with consequent delay in completing the comparisons. The results confirm the conclusion reached during last year's work, namely, that kiln-drying, when properly carried out, has no detrimental influence on the strength of the timber.

The following is a table of the species tested and the general position of the tests as represented by G. for green, A.D. for air-dry and K.D. for kiln-dry. These symbols indicate that the tests on the material in these conditions have been completed.

TABLE OF KILN-TREATED TIMBER UNDER MECHANICAL TEST

Consignment.		Condition.		
15/1	Dutch elm, Wheatfield, Oxon	G.	A.D.	K.D.
15/1/2	,, ,, ,, ...	G.		K.D.
16/1	Wych elm, Needwood, Staffs	G.	A.D.	K.D.
16/1/2	,, ,, ,, ...	G.		K.D.
17/1/2	Black Italian poplar, Sutton Bridge, Lincs	G.	A.D.	K.D.
28/1	Corsican pine, Thoresby, Wilts	G.	A.D.	K.D.
28/1/2	,, ,, ,, ...	G.		K.D.
18/1/2	Oak (mixed) Bedgebury	G.		K.D.
	Oak (mixed) Walcot			
	Oak (mixed) Sessile			
18/1/3	Oak (mixed) Bedgebury	G.		
	Oak (mixed) Walcot			
	Oak (mixed) Sessile			
20/1	Silver fir, Walcot, Salop	G.		K.D.
20/1/2	,, ,, ...	G.		K.D.
14/5/1	European larch, Argyllshire, Scotland	G.	A.D.	K.D.
26/1	Norway spruce, Highclere, Hants	G.		K.D.
32/1	Douglas fir, Longleat, Wilts	G.		K.D.

Strength Tests to compare differing Kiln-drying Processes

Comparative tests have been carried out on two lots of kiln-seasoned ash on behalf of a sporting goods manufacturer. These tests were required to determine if the process to which the ash is subjected in a certain type of commercial kiln is deleterious to the mechanical properties of the timber. The results were compared with results obtained on tests of ash subjected to the usual kiln treatment given to ash used by the firm in question. The tests showed that the kiln-seasoning under the two treatments produced similar mechanical properties which were quite consistent with the final moisture contents obtained in the material after drying.

The Chemical Aspect of the Drying of Timber

The chemical aspect of the drying of timber has continued to receive attention by the Sections of Seasoning and Chemistry. The results of the work on oak wood were published during the year[1] and a study has been completed of the effect of drying on a softwood.[2] The research has shown that hardwoods and softwoods must be expected to react differently to similar drying treatments. Whereas in the case of oak the depletion of total pentosans during air- and kiln-drying is reflected by increases in both the cellulose and lignin components of the wood substance, the depletion of pentosans in silver fir wood is reflected only in slight additions to the lignin. Further in the softwood air-drying

alone induces an addition to the cellulose in the form of a comparatively unstable substance which in the green wood is soluble in water. Apart from the above differences, however, it has been found that, in common with the hardwood, prolonged oven-drying at 105° C. of the softwood results in the hydrolysis of the carbohydrate components of the wood substance. The inference therefore remains that to be commercially successful the kiln-drying of timber must always be a carefully controlled operation.

(1) CAMPBELL, W. G., and BOOTH, J. *Biochem. J.*, 1930, **24** (3), 641–648.
(2) CAMPBELL, W. G., and BOOTH, J. The Chemical Changes resulting from the Drying of Silver fir wood. (*In preparation.*)

Wood Chemistry and Silviculture

In discussing the influence of the site factor on the quality of timber a reference was made in last year's report to a definite disparity in mechanical strength exhibited between two consignments of Corsican pine obtained respectively from Knightswood, in the New Forest, and Holkham, in Norfolk. It is further stated that this disparity could not be explained on anatomical grounds. Chemical data have now been obtained which show that the heartwood of the Holkham material has a slightly lower lignin content than that of the Knightswood material. As the former wood was observed to be the weaker wood mechanically,[1] the suggestion presents itself that this may be explained by the lower lignin content.

(1) The Timber of Corsican pine, *Forest Products Research Bulletin, No.* 6. H.M. Stationery Office (1930). Price 2*s.* 6*d.* net.

Mechanical and Physical Properties of Timber

Tests to determine mechanical and physical properties of timber as represented in small clear specimens obtained from consignments of various species collected from different localities in the kingdom, have been in progress continuously during the year, both on the green and air-dry material. Eleven consignments of various species were collected and these consignments and the localities from which they were taken are tabulated below :—

Specimen	From
Ash	Needwood Forest, Staffordshire.
Ash	Ryston Hall, Norfolk.
Beech	Brocklesby, Lincolnshire.
Beech	Mapledurham, Oxfordshire.
Corsican pine	Castle Hill, Devonshire.
Douglas fir	Aucombe, Longleat, Wiltshire.
Douglas fir	Cannimore, Longleat, Wiltshire.
Norway spruce	Owston Wood, Rutland.
Norway spruce	Stourton, Wiltshire.
Silver fir	Longleat, Wiltshire.
Sitka spruce	Durris, Kincardineshire.
Scots pine	Weasenham, Norfolk.

Of the consignments previously reported as having been tested in the green condition eight reached the standard air-seasoned condition and were converted into specimens and tested. These were represented by the following species :—

Species	From
Pedunculate oak (additional)	Wadhurst, Sussex.
Wych elm	Needwood Forest, Staffordshire.
Black Italian poplar	Sutton Bridge, Lincolnshire.
Pedunculate oak	Bedgebury, Kent.
Scots pine	Walcot, Shropshire.
Silver fir	Walcot, Shropshire.
Spanish chestnut	Delamere, Cheshire.
Beech	Brocklesby, Lincolnshire.

In addition to the necessary procedure attached to the above, reports were completed upon material conditioned previous to 1st January, 1930. These reports included three interim reports on Douglas fir and a final report on the same species which forms part of the bulletin on Douglas fir now in the press,[1] two interim reports on Scots pine, one on beech, and one on black poplar. A small consignment of Sitka spruce from Highclere, Hants, was tested in compression parallel to grain in the green and kiln-dried conditions.

[1] The Timber of Home-grown Douglas Fir. *Forest Products Research Bulletin*, No. 10. (*In the press.*)

Testing of Timber in Structural Sizes

Steady progress has continued to be made in testing structural timbers, in the form of joists and scantlings, in transverse bending. The principle of the test was explained in the last report.

A device manufactured according to the Laboratory's design and specification has proved satisfactory, and the errors introduced in the test, even under the most abnormal conditions, are not greater than the order of 1 per cent., and under the conditions met with in the average test the error is reduced to a degree considerably below this. A similar device is now on order and is expected at the Laboratory early in the new year. This new apparatus will have more than double the capacity of the first design and will be used in testing beams of larger dimensions.

Tests were continued on Archangel deal (*Pinus sylvestris*), 128 pieces of which had been received last year, having been bought at the dockside from merchants as material of standard grade met with in the market. This material had been partly seasoned and when received the moisture in it was below fibre saturation point.

Through the co-operation of an importing firm, the Laboratory was able to obtain freshly converted Swedish redwood (*Pinus sylvestris*) and Swedish whitewood (*Picea excelsa*) : 320 pieces of each of these species in various standard sizes for joists and in grades varying from first to fifth were obtained. The material reached the Laboratory quite green, the moisture contents being well above fibre saturation point. The quantities were divided into two equal parts, the pieces represented in one part being matched with similar ones in the other in each case. One part was put into storage to air-dry, while the other was put into the log pond to remain saturated until tested. Tests have been going forward on this material and during the year the major tests on full-sized structural

specimens numbered 884. In addition to these, 3,158 auxiliary tests were carried out on small, clear specimens obtained from the off-cuts of the material represented in the major tests.

Two consignments of home-grown Scots pine were collected: one of these, 1,500 cubic feet, was obtained from Longleat, Wiltshire, and the second, 1,700 cubic feet, from Douglas Castle, Lanarkshire. These two consignments yielded 509 pieces, comprising 217 from Longleat and 292 from Douglas Castle. This material has also been divided into two lots for testing both green and air-dried and is now awaiting test.

Revision of Existing Specifications for Building Timbers

As reported last year, the Laboratory has been in consultation with the Royal Institute of British Architects, the Timber Trades Federation of the United Kingdom, and with the Building Sub-Committee of the Inter-departmental Works Committee of the Admiralty, War Office, Air Ministry and H.M. Office of Works, over the revision of existing specifications of building timbers. Further conferences have been held from time to time during the year and a great deal of useful work has been done towards clearing away various misunderstandings which exist in many quarters concerning the application of scientific research to the grading of timber in practice and towards co-ordinating the points of view expressed by these different institutions in order to make the way clear to a general acceptance of a national code of grades. There is, perhaps a natural inclination amongst the parties concerned not to accept more clear-cut scientific methods of determining, for instance, the condition of seasoning called for in the specification and to adhere to previous ineffective terms, but it is hoped that this attitude will gradually disappear and that the advantages to be gained by modern methods will be appreciated. At present it is by far the commonest commercial practice, if the dryness of timber is under consideration, to regard it almost solely as a function of the period during which the timber has been in storage or exposed to drying conditions since conversion. This basis is often used in specifying the degree of seasoning in building and other contracts, and while, under certain circumstances, it may be satisfactory enough, in others it may be very misleading, for, apart from the time of storage, other factors affect the result, such as:—

(1) The time of year during which storage takes place,
(2) The local climatic conditions,
(3) The initial moisture conditions of the timber,
(4) Its dimensions,
(5) The manner of stacking,
(6) Whether put into stick or not, and
(7) Whether under cover or not.

It is obvious that moisture content affords a more certain means of defining the condition of timber than any indirect and vague prescriptions based on the period of seasoning. The Forest Products Research Laboratory is a constant advocate of specifying the degree of seasoning in terms of moisture content and hopes to see its early establishment as a general practice in spite of acknowledged difficulties, which are not lessened by some lack of understanding and consequent prejudice. It might be added that such a basis, by fixing a firm but reasonable standard for timber required for various uses, would not in general affect the present practice of reputable and careful timber merchants. They might, indeed, gain from the restrictions placed on less scrupulous merchants.

The specifications recommended by the Laboratory are : –

Timber for :	Moisture content not to exceed	
General carpenters' work	25 per cent.	
High-class carpenters' work	20 ,, ,,	
General joinery work	15 ,, ,,	
Best joinery, block and strip-flooring, panelling and decorative work ..	9–12 ,, ,,	for centrally heated rooms and buildings.
	10–14 ,, ,,	for rooms and buildings not centrally heated.

The moisture content of 25 per cent. specified for general carpenters' work is not low enough to render the timber immune from fungus attack, the minimum content for the development of which is about 20 per cent., but presumes that the timber will season further soon after being placed in the building. In cases where timber is to be treated with preservatives, it is still necessary to season it to about 20 per cent. moisture content prior to treatment, in order to obtain satisfactory impregnation.

In connexion with the revision of specifications, a classification has been compiled, which will be ready for issue early in 1931, of building and structural timbers, which indicates in convenient form those timbers of commercial importance thought to be suitable for the various purposes. While this classification is intended to be of assistance to engineers, architects and other designers, and timber users, irrespective of the source of the timber used, prominence has nevertheless been given, in as much detail as present knowledge permits, to the timbers of the British Empire, whether of home or oversea origin, with an indication of their respective grades where these are known. An additional feature is a table showing the botanical identity of the timbers in question.

Tests on Telegraph Poles

The strength tests on larch telegraph poles reported previously were completed and the report which was mentioned last year as being in preparation is now available.

The material received from the Stores Department of the Post Office for an investigation into the relative strengths of fast grown and slow grown Scots pine telegraph poles was tested. This material (20 poles in all) represented four classes of material, namely, normal growth, creosoted and untreated, and slow growth, also creosoted and untreated.

Although the number of specimens was not great enough to provide authoritative figures of any weight, owing to the possible variations introduced by sampling, yet the results were sufficiently defined to indicate that the standard specifications current for this material are too strict and that slower rates of growth than those officially allowed may be accepted without danger of lowering either the strength value or the property of amenability to creosote treatment.

Preservation Treatment of Telegraph Poles

Work has been completed on the investigation of the creosote treatment of larch poles and a report has been prepared.

In co-operation with the Post Office a number of Baltic redwood telegraph poles have been treated with Wolman salts solution, and with a mixture of Wolman salts solution and fuel oil. These poles have been erected in the line by the Post Office and will be inspected at intervals and a record kept of their durability.

Strength Tests of Cross-arms for Transmission Lines

Conferences have been held between officers of the Laboratory and the Engineering Test Section of the Post Office upon matters pertaining to material used for cross-arms for transmission lines. The Laboratory is assisting in formulating a more concise specification for this material, especially in those clauses relating to condition of seasoning and to mechanical strength. A clause enunciating the seasoning requirements in terms of moisture content has been offered to replace the former indefinite terms relating to the period of seasoning (see page 16 *Revision of Specifications*). The Laboratory is to receive twenty cross-arms, each of home-grown oak and Australian Karri, as representative material upon which to carry out exploratory tests with the view of formulating a practical acceptance test for inspection purposes.

The Strength Properties of Mine Timbers

Following upon the testing of pit-props, an additional investigation was undertaken to compare the mechanical properties developed in transverse bending of Corsican pine, Scots pine, European larch, Douglas fir and Norway spruce; and to compare the results of these tests with those obtained from similar tests upon imported maritime pine, both tapped and untapped. Fifteen specimens of each species of the size used for collars in mine timbering were collected, and these seventy-five specimens were tested in transverse bending with an arrangement of test using four-point loading. It is found that the results of the tests show comparatively wide deviations owing to the variations introduced by sampling which may be expected in material of this class. However, the results are sufficiently consistent to indicate the relative values of the species examined and a report is in preparation.

The Laboratory has been in close touch with the Safety in Mines Research Board and especially with Professor S. M. Dixon, of the City and Guilds (Engineering) College of the Imperial College of Science and Technology. The contact has been very useful in affording an exchange of points of view relating to the requirements expected of mine timbers. The Safety in Mines Research Board has rendered the Laboratory some assistance in the arrangement of the report on pit-props.[1]

[1] Home-grown Pit-props. *Forest Products Research Bulletin, No. 9.* H.M. Stationery Office, 1931. Price 2*s.* 0*d.* net.

Mine Timber Durability Tests

A number of pit-props of both imported and home-grown Scots pine have been treated with different preservatives and placed in two mines, one near Nottingham and the other near Edinburgh. The preservatives used were zinc chloride, sodium fluoride, sodium chloride and Wolman salts, and in one case, at the suggestion of the colliery management, some props treated with creosote were also included.

The treatment was carried out in each case at the colliery itself by the open tank hot and cold process, to demonstrate the simplicity of effective treatment, and considerable interest was shown in the experiments by the colliery officials. Both mines where the props have been placed experience considerable trouble through decay of timber; at one mine a number of untreated control specimens showed signs of fungus attack within six months of being placed in position. These props are to be inspected twice a year.

Decay in Mine Timbers

Further visits have been made to coal mines in which rapid decay of the mine timbers takes place and the species of fungi growing on the props have been collected and identified. Owing to the absence of light and the high humidity in these mines, interesting and abnormal forms occur; these may differ from the typical forms and are sometimes difficult to recognise. It is proposed to undertake a careful survey of the conditions existing in a shallow mine in Scotland, where decay of the timber is rapid and in which a practical test of the value of preservatives in prolonging the life of the props has been started. Careful notes on the temperature and humidity and on the types of decay present will be made. Since the mine is free from gas it will be possible to obtain photographic records of the condition of the treated and the untreated props.

Certificates of Quality in Mechanical Properties

A request from a firm, asking the Laboratory to supply a certificate of quality of Norway spruce, as compared with Scots pine, was satisfied by the issuing of a standard table of strengths of these two timbers as derived from the tests on small clear specimens of timber (Project 1).

Strength of Dowelled Chair Joints

The Laboratory was requested to explore the relative strength of dowelled joints as used in chair construction. It had been claimed by a customer that the chairs produced by a certain manufacturer had proved faulty owing to the dowelling of the joints being varied from that agreed to in the contract. The Laboratory was able to show that the two arrangements of these dowels in the joints were equally strong, and the contention of the manufacturer that the failure of the joints was due to the light construction of the chair, which he had claimed was not suited to the service the chairs were put to, was confirmed.

Plywood Strength Tests

Further requests have been received to test the qualities of various plywoods. These requests are becoming more numerous, apparently owing to the introduction of new timbers in the manufacture of the plies. In some instances this is a matter of comparative tests of the glues employed in the manufacture, and the inquiries dealing with the latter problem are satisfied by the application of the British Standard Test for plywoods.

Glue Strength Tests

There is an indication that glue manufacturers are likely to avail themselves of the facilities afforded at the Laboratory for testing the strength of glues as applied to timber joints. The Laboratory has carried out several series of such tests during the past year and in such cases the glue manufacturers have supplied the glued specimens made in accordance with the standard specifications.

Similar tests have been carried out for the benefit of a firm making wooden wheels. This Company, before placing a large order for adhesives to be used in the manufacture of these wheels, sent a number of specimens, which represented several species of timber, such as were used in their processes, and these in turn were glued with several varieties

of adhesive. As a result of the tests the firm in question was able to confine its consideration to two of the glues, which proved in the tests to be almost equally effective.

Improvements in Apparatus for Mechanical Tests on Small Clear Specimens

The Laboratory is endeavouring to devise a suitable test in compression parallel to grain for small specimens to be used in connexion with certain investigations undertaken by the Section of Timber Mechanics in co-operation with the Sections of Wood Structure, Mycology and Physics. To accomplish this refinement, considerable study has been made of the mechanical methods involved in forming test pieces so as to obtain a test under conditions of the greatest geometrical accuracy. A special turning machine is now being procured which will embody forming cutters to produce these specimens to definite dimensions and with considerable accuracy, without entailing any undue amount of expert manipulation on the part of the machine operator. By means of this improved form of compression test piece it is intended to advance the work taken up jointly by the Sections of Wood Structure and Timber Mechanics to correlate the mechanical characteristics with the characteristics of the cellular arrangement. These specimens will also be used, as mentioned later, in connexion with further tests upon the effect of fungal attack upon the mechanical properties of timber.

As recorded in the last report, the examination of the shear test has been in progress. Further modifications have been made involving a new method of support of the specimen. This new method of support introduces a cross-grain compression instead of the former cross-grain tension, with the result that the incipient splitting encountered owing to the cross-grain tension is now absent. There is a consequent increase in the apparent strength of the specimen under test. Attention is now being given to modifying the shape of specimen in order to permit the full development of strength without introducing local crushing at the support.

Professor E. G. Coker, D.Sc., F.R.S., M.I.Mech.E., of University College, London University, has made some preliminary investigations connected with this shear test, applying his photo-elastic methods. He has demonstrated the system of stresses developed in the various types of test pieces used in this test, and the results of his experiments have been of considerable assistance to the Laboratory. Professor Coker is continuing his experiments.

Abrasion Tests

The Laboratory still continues to receive inquiries necessitating the grading of timbers, principally for flooring, with respect to their property of resisting abrasion and considerable thought has been given to the possibility of devising a suitable test to give this comparison. Several standard abrasion machines have been investigated, but although some of the machines have produced results which appeared to give a satisfactory indication of the relative values of the timbers under test, yet it was found that the conditions governing the test in the machines cannot be maintained as constants and thus a standard test could not be defined. One type of abrasion machine, namely, the " sand blast," was found to be unsuitable, owing to the fact that the test affected the softer fibres, leaving the hard rings almost untouched. It is the dense fibre in a flooring timber that carries the traffic and is the chief agent in resisting the wear so produced. This feature has led to the decision that the sand blast is not desirable as an abrasion test for flooring timbers. The investigations are still going on and the Laboratory is being assisted by the Timber Mechanics Committee in its efforts to obtain a suitable test.

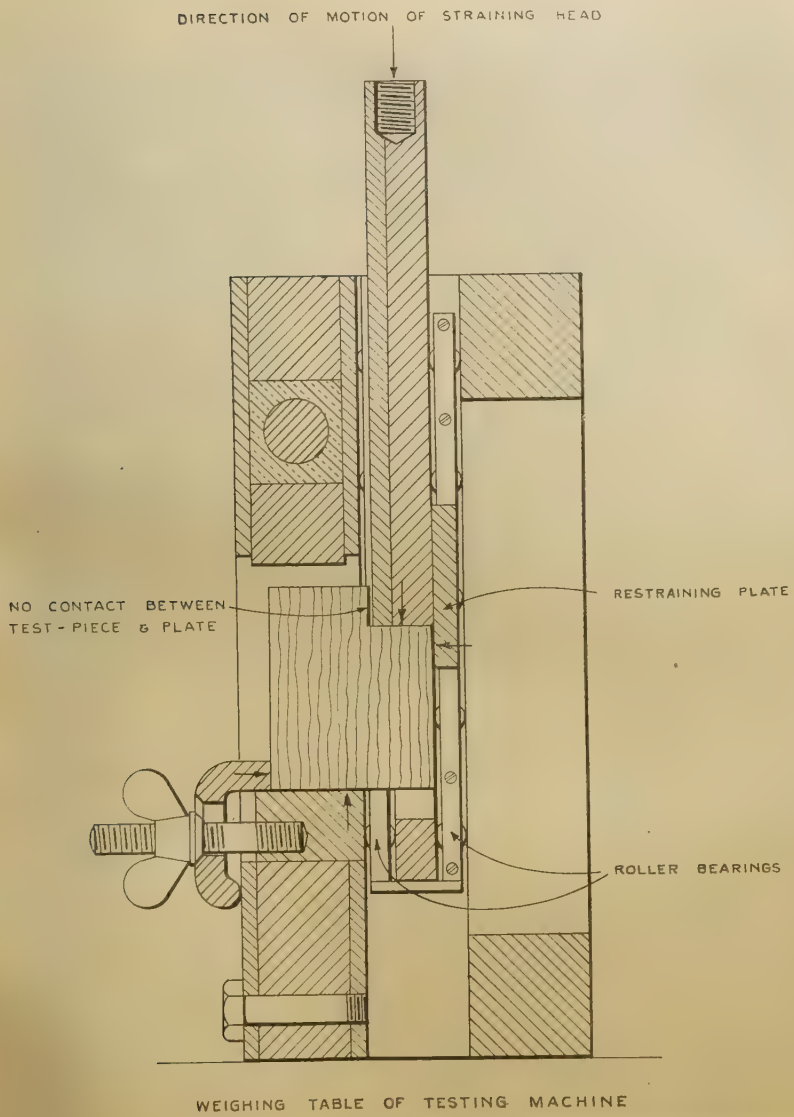

DIRECTION OF MOTION OF STRAINING HEAD
NO CONTACT BETWEEN TEST-PIECE & PLATE
RESTRAINING PLATE
ROLLER BEARINGS
WEIGHING TABLE OF TESTING MACHINE

FIG. 4.—*Modified design of Shear Test Apparatus as developed at the Laboratory.*

Timber Mechanics Committee

The Laboratory has been carrying out various tests at the request of the Timber Mechanics Committee, and has reported on various investigations into the conditions of test represented in the standard methods employed for small clear specimens. Reports have been submitted upon the impact test, the shear test and the test for hardness. A report on compression perpendicular to grain was also made in which it was shown that the strength of timber in compression in this direction up to the limit of proportionality of stress to strain was independent of the area under compression.

Professor Coker has also carried out photo-elastic experiments upon specimens similar in shape to those used in cleavage and tension across the grain, and the results of his test are contained in the paper which he read before the Royal Society last June. The general conclusion he reached is that the system of stresses introduced in specimens of these shapes during test is very complex. At the same time he points out that the material upon which he worked is isotropic and it is difficult to say how far timber allows a similar development of stresses before failure. As a result of this report further tests are being carried out in which carefully turned specimens will be compared with standard specimens in tension across the grain to determine whether or not there is any correlation between the strengths developed by the two types of specimen.

In addition to the shear test, tests to determine the shear stress in timber parallel to the grain have been reported on. These tests employed specimens, cut with the principal axis at various angles to the grain between 0° and 90°, to which the compressive force was applied in a direction parallel to the axis. Scots pine in the green condition was the timber used in these tests and the grade was selected with particular care. The result of these tests shows that Scots pine will fail in compression parallel to grain until the grain is inclined at an angle of about 10° to the axis, when it will begin to fail in shear and will continue to do so until the inclination of the grain to the axis is increased to about 30°, after which it will fail in crushing perpendicularly to grain (see Fig. 5).

Deterioration in the Strength of Timber at Various Stages of Decay

Co-operation between the Sections of Mycology, Chemistry and Timber Mechanics has resulted in certain definite findings with regard to the strength of timber decayed by *Trametes serialis*. The results, which are now being prepared for publication, show that in the incipient stages of decay a certain amount of chemical decomposition with consequent loss of strength takes place before there is any marked loss in weight and before the presence of fungus can be detected with the naked eye. Speaking generally, it may be said that immediately wood begins to decay it begins to decline in strength and that the extent of the decline in strength is directly proportional to the degree of chemical decomposition brought about by the action of the fungus. The research has brought to light the important conclusion that the decreased strength of decayed wood results from the chemical decomposition of the cell wall substance rather than from the purely physical disintegration of the walls by hyphal penetration.

Research on the chemistry of the white rots of wood is still in progress and results have been published[1] on the effect of *Polystictus versicolor* (Linn.) Fr. on the wood of beech and ash.

It has been clearly demonstrated for the first time that the white rots which hitherto were reputed to attack only the lignin component of wood substance also attack the carbohydrate components. Further, it has been determined that in the decay of beech

FIG. 5.—*Showing the Types of Failures in a Series of Test Pieces cut at varying angles to the Grain.*

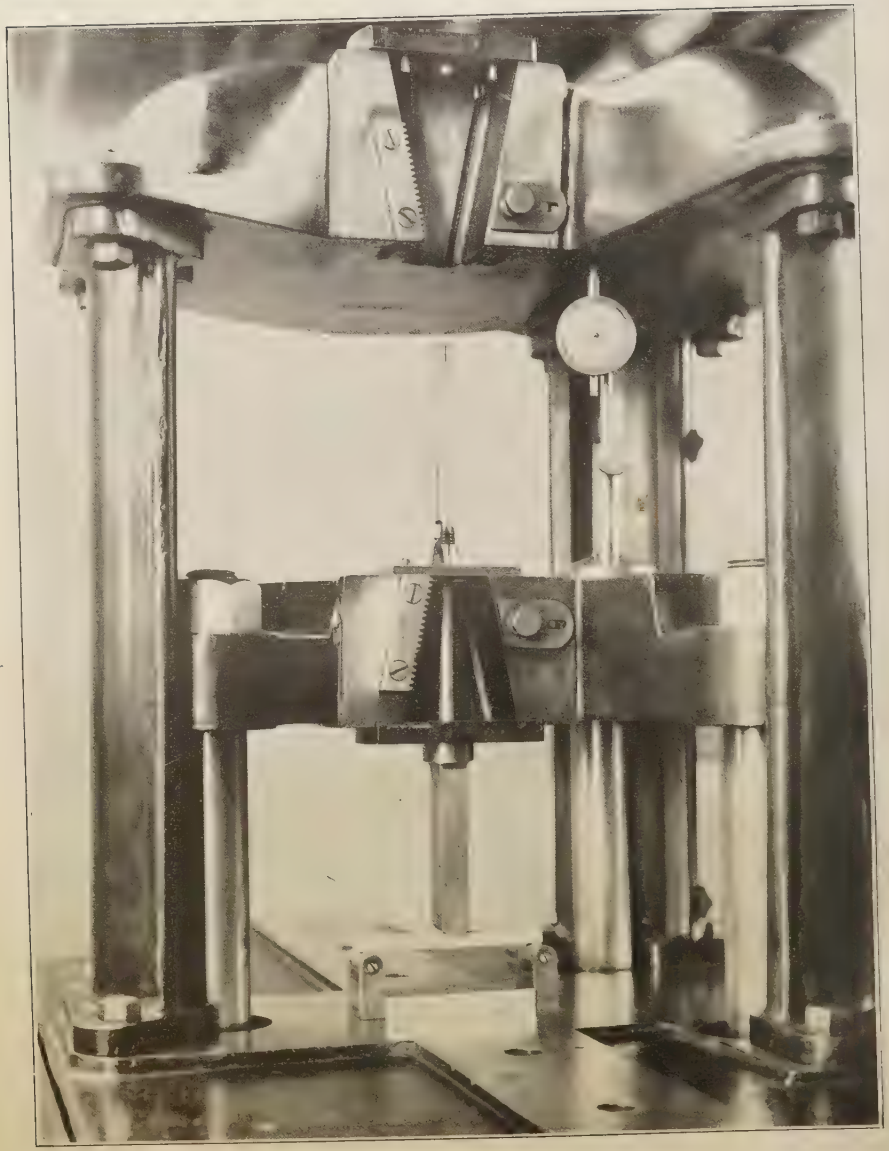


FIG. 6.—*Arrangement of the Static Bending Test used in the investigation of the Influence of Fungal Attack upon Strength.*

and ash woods caused by *P. versicolor* the principal components are attacked in a definite order. The pentosans and lignin are the first components to be attacked, and of these the pentosans not in the cellulose suffer most depletion. As decay becomes more advanced the rate at which pentosans are depleted is diminished, and preferential attack is made on the cellulose proper as well as on the lignin. From the experimental results the theory has been advanced that the fungus secretes an oxidase which acts upon lignin and pentosans to produce acid. Further simultaneous action of oxidase and acid completes the process of decomposition in which the cellulose proper is depleted. Thus it has been established that although acid is produced during both "brown" and "white" rots of wood, the nature of the decomposition in the two types of rot is chemically essentially different.

(1) Campbell, W. G. The Chemistry of the White Rots of Wood. 1. The Effect on Wood Substance of *Polystictus versicolor* (Linn.) Fr. *Biochem. J.*, 1930, **24** (4), 1235–43.

Laboratory Tests of Wood Preservatives

The results of the tests upon antiseptics in wood blocks, referred to in the last annual report, have suggested various modifications to the details of technique and a further number of preliminary experiments have been carried out to test these. Only two kinds of wood (Scots pine and beech) are now used in the laboratory tests, but it has been found necessary to employ more than one species of fungus in making the tests because fungi vary in their reaction to antiseptics to a surprising degree; one fungus that is particularly resistant to certain preservatives will be susceptible to others, and so on. *Fomes annosus*, the species used largely in agar tests in the United States Laboratories, has proved unsuitable for use with wood blocks; even when it is making apparently good growth, it is incapable of causing the significant losses in weight, which are the most useful criteria of the amount of attack. It has been decided to employ *Coniophora cerebella*, together with *Lentinus lepideus* (= *L. squamosus*), for tests with Scots pine wood blocks, while *Polystictus versicolor* will be used for testing the treated beech blocks.

Further agar tests have been carried out in which *Coniophora cerebella* and *Fomes annosus* have been used as test fungi.

An international conference on methods of determining the toxicity of wood preservatives, held in Berlin in June, 1930, was attended by one of the staff of the Section of Mycology. An account of the conclusions arrived at by this conference has been published.[1] It was generally agreed by the conference that, while agar tests are of value in obtaining a rough idea of the value of a preservative, wood block tests are likely to give a truer value for the toxicity of a wood preservative. No final estimate of the value of an antiseptic in practice can, however, be based solely upon its toxicity; other factors, such as its stability in the wood and its resistance to leaching, must also be taken into account. As an outcome of the conference the Laboratory is participating in an experiment which is being undertaken co-operatively by a number of research institutes in order to arrive at certain standard methods upon which it will be possible to agree. The general employment of such methods will render results obtained in different centres of research internationally comparable. As a first step an effort is being made to choose one single vigorous strain of *Coniophora cerebella*, which would be used for all standard toxicity experiments. These experiments will also determine how far the wood block method is capable of producing constant results when carried out by different workers.

[1] The Testing of Wood Preservatives. *Nature*, December 13th, 1930.

Field Tests on Wood Preservatives

Work has continued on the preparation, treatment and placing of specimens for the field tests in connexion with the standard scheme for testing preservatives described in last year's report. Additional sites have been chosen, one in North Wales, at an altitude of about 900 feet, where the soil is mainly peat, and one in Norfolk, at an altitude of about 100 feet, where the soil is practically pure sand. Together with the site at Princes Risborough, where the soil is mainly chalk and clay, a fair average of soil and climatic conditions is thus obtained. Arrangements have been made to test low temperature coal tar and its distillates under this scheme. In this work the Laboratory is in touch with the Fuel Research Station and Chemical Research Laboratory of the Department.

The construction of the Toxicity chamber, mentioned in last year's report, was completed during the year. The chamber is now in operation, and is proving satisfactory. In it treated and untreated specimens can be placed under controlled conditions of temperature most suitable to fungus growth. The investigations in this chamber, apart from giving accelerated large scale tests on preservatives in general, will also serve to mark those preservatives suitable for interior work but which are not suitable for exterior work, such as sleepers, telegraph poles and the like.

Impregnation Tests

The measurement of the adaptability of different species to pressure treatment with antiseptics has received consideration. A number of specimens of standard size, 2 in. × 2 in. × 3 ft. 6 in. long, have been treated with creosote by a standard process and the figures for absorption used to obtain a measure of the adaptability of the species to treatment. This method has certain disadvantages, mainly the difficulty of obtaining comparable sticks of different species and also the proportionately heavy absorption due to end-penetration. The elimination of the effect of end-penetration is being considered and attempts are being made to measure the rate of penetration of a preservative in a lateral direction, both radially and tangentially, under a standardised pressure.

British Wood Preserving Association

The British Wood Preserving Association was formed last year on the lines of the American Wood Preservers' Association, and the Laboratory is represented on the Council. The Laboratory's co-operation has been particularly sought in the compiling of authentic records of the durability of treated and untreated wood in actual use and a circular has been issued by the Association to its members asking for such information. A note on the butt treatment of fence posts was prepared for the Association and has been printed by them in leaflet form and widely distributed among estate owners.[1]

[1] The Butt Treatment of Fence Posts. Published by the *British Wood Preserving Association*, 166, Piccadilly, W.1.

Dry Rot Investigations

The construction of the small experimental house, described in detail in last year's report, in which the development of a dry rot attack may be studied and where control and preventative measures may be tried out, is now nearly complete. It is particularly wished to have opportunities of testing methods for the sterilization of joists and other

To face page 24

FIG. 7.—*Interior of constant temperature chamber for the testing of wood preservatives. Duck-boarding in part removed to show water on floor. Note series of treated and control specimens, each with piece of infected wood attached.*

FIG. 8.—*Experimental house for the study of Dry Rot and Death-Watch Beetle.*

large members *in situ*, as it is frequently necessary to remove infected wood that is mechanically sound in order to prevent subsequent spread of infection, a proceeding which often involves great expense.

Inquiries have been received as to the relative resistance of various makes of "wall boards" to attack by dry rot, and a number of proprietary brands of wall boards have been exposed to severe attack by *Merulius lacrymans*. It has been found that the looser and more fibrous class of boards, made from vegetable residues, is more susceptible to decay than the closer, harder and more laminated type.

Identification, Life History and Physiology of Wood-destroying Fungi

The collection of wood-destroying fungi in culture at the Laboratory has been increased by the addition of a number of new isolations and it now includes over 130 species. The Section of Mycology is in touch with the work of similar institutes abroad where the subject of timber decay is studied, and in addition to the interchange of reprints of published work a considerable number of cultures of wood fungi have been interchanged with Laboratories in America, Germany and Holland. A visit by one of the Mycologists was made to the Central Bureau for Fungus Cultures at Baarn, Holland, and the methods used there for the culturing of fungi were examined.

Progress in the description of the cultures has been made and analytical keys are being prepared whereby it will be possible to identify a fungus from its culture provided that the species of timber from which it has been obtained is known. A preliminary account of the methods used for the diagnosis of the cause of decay in timber was given at the 1930 meeting of the British Association and has subsequently been published.[1] It has been decided that for the present the keys shall be limited to the more important fungi which occur on well-known species of timber. Attention is first to be concentrated upon the complete description of those fungi which occur commonly upon coniferous timber in this country and, in addition to the details of their cultures, their effects upon the timbers will be described and the microscopic details of their mycelium in the wood noted. Numerous additions have been made to the collection of microscopic preparations of various timbers decayed by different fungi and to the collection of typical rots produced by these fungi.

The study of *Paxillus panuoides* has been completed and a report of this work is now in the course of preparation. This fungus, which is capable of causing an active brown rot of coniferous timber, is of frequent occurrence in coal mines and occasionally makes its appearance in very damp houses. It demands for its growth a high moisture content in the wood, but at the same time requires a plentiful supply of oxygen. It finds these conditions in sawdust heaps, where it is commonly found. It readily forms fruit bodies in cultures upon malt agar acidified with malic acid, when these are placed in diffuse light. The amount of light required for the production of the fruit bodies of this fungus must be extremely slight, because perfectly developed specimens frequently occur in coal mines.

The temperature relations for a number of the more important wood-destroying fungi have been determined and curves have been prepared showing the relative rates of growth at different temperatures. This work is still in progress and a report upon the results so far obtained will shortly be prepared.

The development of fruit bodies in culture of fungi belonging to the Basidiomycetes is of interest not only because it enables the cultures to be more readily recognised, but because some of the abnormal structures which are produced raise interesting problems in morphology; frequently the type of fruiting body produced in culture is characteristic

of species less differentiated and presumably less highly evolved. Experiments are in progress to determine the effect of the concentration of the food material in the medium upon the number and nature of the fruit bodies produced.

[1] Cartwright, K. St. G., and Findlay, W. P. K. The Diagnosis of Decay in Timber. *Empire Forestry Journal*, 1930, **9**, No. 2.

Timber Insect Survey

One of the most important insect problems which still confronts the hardwood sections of the Timber Trade and manufacturers using hardwood timbers is the occurrence and spread of damage caused by *Lyctus* powder-post beetles. Reference has been made in previous annual reports and in other publications of the Laboratory to the work that has been carried out upon this problem.[1] It has been pointed out that it was desirable to collect data upon the occurrence and distribution of *Lyctus* in imported and home-grown hardwoods throughout the country. For this purpose the Laboratory has undertaken a timber insect survey of the chief ports, of timber yards, and of the premises of the manufacturers concerned. The main objects of the survey have been set forth in the report for the period ended 31st December, 1929. The year now under review is the second during which this survey has been in progress. During this period investigations have been carried out chiefly in the London docks, as well as in timber yards and other premises in the London district. In addition, visits have been made to yards and factories in a number of other towns, including Birmingham, Gloucester, Hull, Leeds, Sheffield and Stroud. The field work of the survey was brought to a close during October, 1930. Together with the visits made during 1929, the survey has covered all the important timber centres throughout England and Scotland. Information has been collected chiefly upon the occurrence of *Lyctus* beetles, but attention has also been paid to the extent of injury caused by other wood-boring insects—for example, Pin-hole borers, Longhorn beetles and Bostrychid powder-post beetles. The survey collection consists of specimens of insects and their larvæ collected during the field work, and also a representative selection of specimens of timber showing different types of defect caused by insects. Confidential reports have been prepared upon the conditions found in a number of the districts visited during 1929 and these have been made available to the federations and associations concerned. Information, when requested, has also been supplied to individual firms with regard to the conditions found in their own stocks. In one instance a special lecture was delivered to the members of a trade federation in an important wood-using industry, when, at their own request, an account was given of the results of the survey in their district. A report for publication has not yet been prepared, as it was intended to await the completion of the field work of 1930 before writing a general account of the conditions with regard to insect damage to hardwoods throughout the country as a whole.

[1] Fisher, R. C. *Lyctus* Powder-post Beetles. *Forest Products Research Bulletin*, No. 2. H.M. Stationery Office, 1928. 3*s*. net.

Control Measures against Lyctus

A direct result of the survey has been apparent in the general interest in insect damage to timber that has been aroused throughout the timber trades. In a number of instances it has been noted that special steps are now being taken by manufacturers and merchants to attempt to control and restrict the spread of *Lyctus* beetles. Firms possessing suitable kilns submit infested or suspected timber to the sterilization

treatment described in *Forest Products Research Laboratory Bulletin*, No. 2.[1] Where kilns are not available, other firms are now carrying out a regular system of inspection of their stocks, together with segregation of attacked material, followed as far as possible by the elimination and destruction of infested sapwood. The Laboratory has been approached on many occasions for advice upon *Lyctus* infestation and it is apparent that there is an increasing realization of the significance and importance of insect damage to timber.

During the past year work has been in progress with a view to revising the conditions of temperature and humidity required for the sterilization of timber in a kiln. Previous work has indicated that a temperature of 125° F. at 80 per cent. relative humidity maintained for a requisite period would be sufficient for the destruction of the insect. A series of experiments has provided information concerning the lethal conditions of time, temperature and humidity, using larvæ which have been removed from the wood in which they were living. Further information is, however, required, particularly upon the humidity conditions prevailing within the wood, under known conditions of temperature and humidity in the surrounding atmosphere, before it will be possible to draw up a schedule for kiln sterilization treatment of *Lyctus*-infected timber at temperatures less than 130° F. and at relative humidities less than 100 per cent.

Susceptibility of Timber to Lyctus Attack

A subject of particular importance to which attention has been paid concerns the species of timbers and their condition in relation to susceptibility to attack by *Lyctus*. Earlier work (Clarke, 1928)[1] has shown that timbers possessing large vessels are more liable to infestation than timbers with small vessels; thus oak, ash and walnut are frequently attacked, whilst only one instance each of attack in sycamore and willow has been noted in Laboratory and survey records. No instances have been obtained of beech or birch being infested by *Lyctus* in this country, but in the United States there are records of severe infestations in birch. Experiments have been started from which it is hoped to determine whether *Lyctus* can deposit its eggs within the pores of a number of hardwoods (including timbers with small pores) or, failing this, whether, given a suitable wood for oviposition, the young larvæ on emerging can extend their tunnels from such a wood into a small-pored timber. For this purpose the timbers used are the common commercial hardwoods of this country, together with a number of Australian hardwoods, upon which work has now been in progress during two summers. As part of this work, a study is being made of the eggs of the different species of *Lyctus* concerned and of the details of oviposition. The range of vessel size in the timbers used is being determined by the Laboratory's Section of Wood Structure.

It is known that the *Lyctus* beetles attack timber during or soon after seasoning. Evidence has been obtained to show also that the susceptibility to attack is to a certain extent governed by the moisture content of the wood (Fisher, 1928).[2] Further, the Laboratory's Section of Chemistry has demonstrated that the frass produced by the larvæ of *Lyctus* is in every respect similar in composition to sound oak sapwood and the indications are therefore that the larvæ do not feed on the cell wall substance of the wood (Campbell, 1929).[3] Apparently the insect must derive its nourishment from certain cell contents of the sapwood, which either disappear or alter as the timber ages and which are not present in heartwood. Such an hypothesis is supported by the fact that heartwood is not attacked by *Lyctus* and also because, as the timber ages, its suitability for the development of *Lyctus* decreases. It has not been possible during the past year to

develop to any great extent this side of the investigation, but work is in progress to ascertain the effect upon the liability to *Lyctus* attack of oak sapwood leached in various neutral solvents. It is possible that if the insect depends upon the cell contents of the sapwood for its nourishment, these may be dissolved or washed out and the wood thereby made unsuitable for the insect. In the same connexion the comparative susceptibility to attack of air-dried and kiln-dried oak is being tested.

(1) Clarke, S. H. On the Relationship between Vessel Size and Liability to Attack by *Lyctus*. *Forestry*, 1928, **2** (1), 46.

(2) Fisher, R. C. Timbers and their Conditions in Relation to *Lyctus* Attack. *Forestry*, 1928, **2** (1), 40–46.

(3) Campbell, W. G. Chemical Aspect of the Destruction of Oak Wood by Powder-post and Death-watch Beetles, *Lyctus* spp. and *Xestobium* sp. *Brochem. J.*, 1929, **23** (3), 566–725.

Furniture Beetles

The Laboratory has continued its investigations into the biology of the Death-watch beetle, *Xestobium rufo-villosum*, and of the Common Furniture beetle, *Anobium punctatum*.

As in previous years, one of the chief difficulties in carrying out this work has been to secure adequate stocks of infested timber from which to obtain beetles for experimental work. This difficulty is still a serious handicap to progress, especially in the case of the Death-watch beetle. Efforts have been made to collect infested timber with the help of architects, builders and others concerned in the repair of buildings where damage has been caused by these insects. While it is difficult to obtain quantities of timber showing signs of injury by *Xestobium*, it is much more difficult to find timber in which this insect is still working. This would seem clearly to indicate that in many instances where the Death-watch Beetle has been "discovered," it is doubtful whether the insect is always present; it is more likely that the damage caused is of long standing and has only recently been noticed. At Princes Risborough large quantities of timber showing the characteristic Death-watch injury have been cut up for examination and, in general, the numbers of insects found have been extremely small. It would seem advisable, therefore, that when repairs in a building are contemplated, special attention should be paid to these points in an attempt to ascertain whether the beetle is still present before a costly treatment of timbers which may contain nothing alive is undertaken. In this connexion it is recommended that a thorough inspection of the suspected timbers should be made by a competent entomologist in conjunction with an architect, and, if possible, a sample should be removed and cut up for exhaustive examination. Signs of Death-watch beetle injury in a building do not always indicate serious decay, and do not necessarily mean that extensive alterations or repairs should at once be carried out.

Progress has been made in the study of the life-history of *Xestobium* and the conditions suitable for its development. In the last annual report reference was made to the relation between moisture content conditions in timber and the rate of development of the insect. Last year's experiments have been repeated with a more suitable technique which is proving satisfactory, and the work will be extended to include a study of the insect under conditions of controlled humidity and temperature. The erection of the special building, described in the last report, for the study on a large scale of dry-rot and Death-watch beetle, was almost complete towards the end of the year and work will be begun during the ensuing year.

In the studies of the Common Furniture beetle, *Anobium punctatum*, general infestation experiments, begun in the summer of 1927, have yielded results during the past

year. Adult beetles emerged in July, 1930, from samples of *Cotoneaster* wood first infested in 1927. Under normal laboratory conditions the life-cycle of *Anobium* in this work has therefore occupied three years. Examination of a series of similar experiments started in 1929 shows that the development of larvæ of *Anobium* in walnut has been more rapid than in other woods; for example, larvæ which emerged from eggs laid in walnut in August, 1929, were found to be almost half-grown in December, 1930. On the other hand, larvæ which hatched from eggs laid in beech about the same time are not nearly so far advanced, although kept under similar conditions. There seems to be evidence that walnut is particularly favourable for the development of *Anobium*. Further information is still required on the different conditions which may influence the duration of the life-cycle of this insect. In this connexion, a study of the relationship between the moisture content of timber and its suceptibility to attack has yielded some preliminary results which require confirmation from experiments carried out on a larger scale, similar to those in progress with the Death-watch beetle.

Symbiosis of Fungi and Insects

The relation of the presence of fungus attack in timber to the occurrence of wood boring beetles has continued to receive attention. Artificial infestation of samples of oak and willow with species of fungi cultured from timbers containing Death-watch beetle has again been carried out. Fungus attack was allowed to develop for two to three months before *Xestobium* beetles were added to the experiment. Work is still proceeding and records are being kept of the rate of development of the few larvæ, emerged from eggs laid on these samples, which have succeeded in establishing themselves in the blocks of fungus-infested wood. In continuation of this part of the work on *Xestobium* and in connexion with the experiments which were carried out by the Laboratory in 1929 on the chemical aspect (Campbell, 1929)[1] of the feeding of *Xestobium* and *Lyctus*, it was decided to undertake an investigation on this subject from the more purely biological side. It has been known for some time that a large number of wood-boring insects harbour internally, usually in close relation to the alimentary canal, micro-organisms which apparently aid the insect in the assimilation of wood. This phenomenon of symbiosis has already been shown to exist in the wood-boring *Anobiidae*, and a valuable paper on this subject has been published by Breitsprecher (1928).[2]

Early in the year a quantity of material was prepared for examination by dissection and section-cutting, and although good headway was made at first with this material, the investigation had later to be suspended owing to pressure of other work; it is intended to resume the investigation as soon as time permits. All the work so far carried out on *Xestobium* and *Anobium*, the two principal wood-boring genera of the family, confirms the results published by Breitsprecher and, furthermore, the presence of yeasts in the mesenteric caeca has also been demonstrated in the larva of *Ptilinus pectinicornis* (Fisher and Parkin, 1930).[3] Dissections of adults have borne out Breitsprecher's account of the complexity of the relationship between beetles and yeasts.

Although previous workers have suggested that the yeasts may play an important part in the physiology of digestion of these insects, no information has yet been obtained to prove or disprove this. Attempts were therefore made to culture the yeasts from *Xestobium* and *Anobium* on artificial media, so that their effect on cellulose or other wood constituents could then be observed. Although several cultures of yeasts were obtained no proof was forthcoming that the yeasts cultured were the same as those present in the gut wall of the insect; in one or two instances the yeasts in culture were shown definitely not to be those in question. The culture of such symbiotic yeasts is an extremely difficult

task and much preliminary work must be carried out before any hope of success can be entertained. Nevertheless, in order to understand how the Death-watch beetle, for instance, derives its nourishment from wood, such investigations are essential.

When material was being collected for the above-mentioned work on symbiosis, some difficulty was found in determining the species to which some of the larvæ belonged; this trouble was also experienced in connexion with advisory work. Existing keys have been found to be unsatisfactory or incorrect on certain points, and work is now in progress with the object of making detailed descriptions of several species of *Anobiid* larvæ in order to facilitate their identification. Different keys are required for the identification of living larvæ which it is not desired to kill and dissect, and for dead, shrunken larvæ or cast skins, necessitating preparation on slides for examination under a microscope.

[8] Campbell, W. G. Chemical Aspect of the Destruction of Oak Wood by Powder-post and Death-watch Beetles *Lyctus* spp. and *Xestobium* sp. *Biochem. J.*, 1929, **23** (6), 1290–1293.

[9] Breitenbecher, F. Beitrage zur Kenntniss der Anobiiden Symbiose Zeitschr. Morph. Ökol. Tiere, 1928, II (pts. 3 and 4), 495 et seq.

[10] Fisher, R. C., and Parkin, E. A. Presence of a Yeast in the Death-watch beetle, *Xestobium rufo-villosum* De G. *Nature*, 1930, **125**, 892.

Sirex Wood Wasps (Siricidae) and Fungus Association

The investigation which is being carried out in co-operation with the Imperial Forestry Institute, Oxford, into the fungus relationship found in the *Siricidae*[11] (Cartwright, 1929), has been in abeyance: owing to pressure of work consequent on the death of Dr. Carystal's assistant, fresh material was not available. Serial sections, however, have been prepared through pupæ of *Sirex cyaneus* and these are now under examination. It is intended to proceed further with the work on the receipt of further supplies of insects.

[11] Cartwright, K. St. G. Notes on a Fungus Association with *Sirex cyaneus*. *Ann. App., Biol.*, 1929, **16** (1), 182–187.

Standard Tests of Wood Preservatives for Prevention of Insect Attack

A scheme of work under which a series of standard tests of wood preservatives are being carried out was fully outlined in the last report. During the past year, experiments carried out in 1929 to determine the toxicity value against insect attack of zinc chloride and a proprietary salt, have been repeated and the results confirmed. Laboratory tests of antiseptics are at present being carried out only with oak sapwood exposed to attack by *Lyctus* Powder-post beetles. Material of other wood-boring insects is not available in sufficient quantity and existing knowledge of their biology is too scanty at present to justify an extension of this type of work. In addition to the tests mentioned above, a number of treated and untreated control samples have been placed in certain buildings, by permission of H.M. Office of Works and other authorities, in the vicinity of timber attacked by the Death-watch beetle.

X-Rays in the Detection of Insect Attack

A few preliminary experiments have been made on the use of X-rays in the detection of insect attack in wood. These experiments were partially successful in showing up quite small larvæ in samples of wood half an inch thick. It is not contemplated that X-rays could be used on large pieces of wood in buildings, but the usefulness of the method can be appreciated when it is realized that in many cases it is not possible to detect the

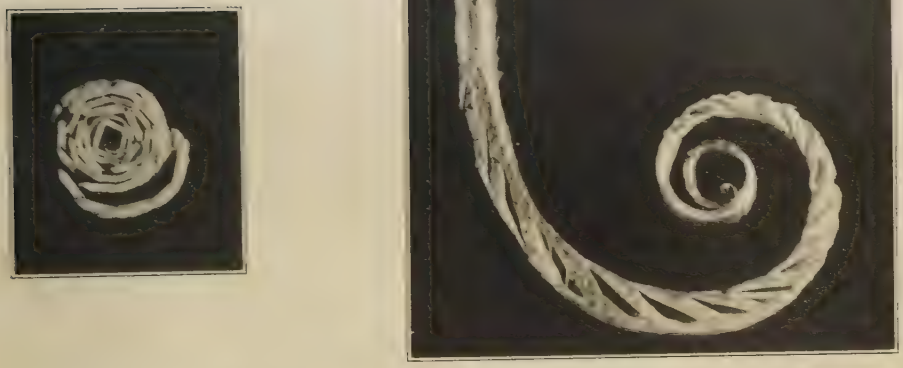
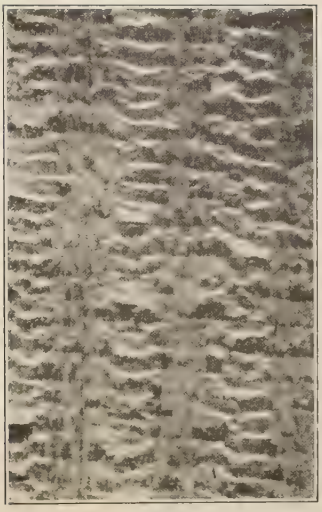
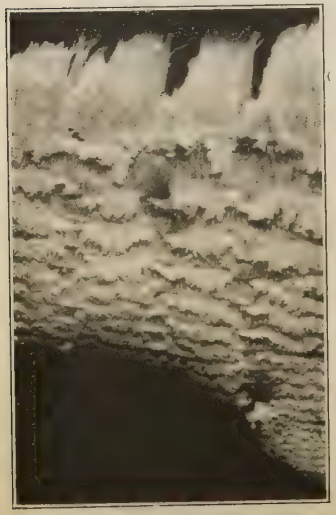


Fig. 9x. — A very small shell. Shell with the animal.



Convex.

Concave.



Convex.

Concave.

The two sides of a shaving compared.

In the upper pictures, a shaving from a hand plane. In the lower pictures, a shaving from a machine planer.

On the convex side the ends of the rifts are seen, while on the concave side the horizontal white lines show the points of periodic failure in compression. The blade of the plane travelled in a direction upwards from the foot of the page. (Magnification × 5).

FIG. 9B.—*The Formation of a Wood Shaving.*

presence of insects even in a small sample without breaking it up into fragments. These preliminary experiments are being continued by the National Physical Laboratory in order to obtain further indication of the possibilities of the method before deciding on the purchase of an X-ray outfit for the Laboratory.

The Working and Finishing Qualities of Wood

The machining qualities of wood are of considerable importance in utilization, since finish obtainable is in many cases of greater importance than mechanical strength in the choice of wood for furniture-making and decoration.

An outline was given in the report for last year of the principles upon which the study of the working and finishing qualities of wood has been based, and it was stated that research had been directed towards the formation of a working plan to investigate these qualities according to definite standard methods, employing standard tools, and devised so as to be as independent as possible of the personal factor. It was stated that red deal (*Pinus sylvestris* L.) has been taken as the basis for comparison in softwoods and beech (*Fagus sylvatica* L.) for hardwoods.

Tests under a provisional project have been made on a large number of woods and the results, in addition to providing useful information upon working qualities, have indicated directions in which the working plan may be improved. "Machinability" is at present a somewhat vague term, involving a balance of several factors, such as power consumption by the machine and the smoothness obtainable in the finished wood. The Section of Physics is endeavouring to give exact definition to these factors in machinability by correlating the power consumption to the elastic properties of the wood as determined in the Section of Timber Mechanics, and in devising some method of judging finish which does not depend on the opinion of the individual judge. The difficulties met with in the first of these problems are considerable, as most machining involves stressing some portion of the wood beyond the limit of proportionality. This is clearly shown in the simple case of the shaving delivered from the hand plane—the fibres of the shaving have been bent beyond the limit of proportionality and so it remains permanently curled up.

Charcoal-making in Portable Kilns

The investigations, described in last year's report, in connexion with charcoal-making in portable metal kilns have approached their conclusion during the current year. The final stage should be completed by the summer of next year and a report will then be published.

After exhaustive experiments with different types of kiln and various modifications to them, a final design has been approved and is being patented. Its chief features are that the height and base area are those which have been observed to give an optimum yield with the minimum time in carbonization; the height and capacity facilitate its erection and the stacking of the timber to be carbonized; the weight of the side and top sections is approximately 100 lb. each, thus making them capable of being handled and carried for short distances by two men; while the joints are of special design for simplicity of erection and assembly of the various parts.

From observations made it seems probable that a battery of such kilns—the number varying according to local conditions, possibly from three to six—could be managed by two men so as to give a constant sequence of burning with a definite expectancy of yield of charcoal per week. While many of the troublesome factors in design have been overcome by laboratory experiment under limited conditions of use, it is still necessary

definitely to test the possibilities of working such kilns profitably under commercial conditions and, at the same time, to demonstrate the extent to which portable kilns are superior to the earth-kiln in making charcoal. In earth-kilns constant attention is needed during carbonization, and plenty of water is required to extinguish the charcoal before extraction, whereas with the iron kilns tested at the Laboratory it has been possible to eliminate night attention during the period of burning and the use of water before extracting the charcoal. When the new kiln has been completed, it has been arranged to carry out this commercial trial on a felling area in the woods.

The laboratory investigations have involved systematic burnings in each kiln over a prolonged period, with observations upon the species and size of the wood used, its moisture content before carbonization, the time taken to carbonize and the yield of charcoal, the quality of the charcoal by analysis, its suitability for commercial purposes, and the ultimate effect of the heat upon the several parts of the kilns. The material used has consisted of waste wood, representing many species of timber, from the sawmill and wood workshops of the Laboratory, and also branchwood from forestry operations, the species used being beech and birch. In the latter case, tests have been carried out to find the maximum thicknesses at which it is possible to carbonize large branchwood. Provided the kilns are regulated suitably, logs and similar material up to eight inches in diameter could be carbonized in comparatively little more time than is required for smaller material; a possibility therefore here exists for a saving in the cost of splitting such material before carbonization. The best charcoal has, however, so far been found to be produced by branchwood about one inch in diameter.

Experimental work has also been directed towards the preparation of charcoal at high temperatures, with the object of producing a slightly activated material for special purposes. It is hoped that charcoal of this nature from waste wood, though possibly not a substitute for the activated product from bone and shells, may command a better price than the ordinary commercial product. Extensive temperature readings have been taken in the various kilns in connexion with this possible development.

Several inquiries from this country, from India, Africa and other parts of the world, have been dealt with, mostly from those requiring information about portable metal kilns and wishing to know their possibilities under various local conditions.

The Composition of Wood Smoke used in the Curing of Fish

At the request of the Food Investigation Board, the Laboratory has undertaken to investigate the composition of wood smoke in order to gain further information as to the constituents which are instrumental in curing fish and further to try and evolve a simple means of producing the most effective type of fish-curing smoke. In co-operation with the Torry Research Station, Aberdeen, it has been possible to obtain samples of condensed smoke and qualitative analyses of these have been made. A condensate from Scots pine sawdust was separated into (1) an aqueous acid liquor and (2) tar. The former contains acetic and formic acids which have been separated as to their calcium salts. It also contains a small proportion (3·5 c.c. per litre) of an oil in the form of an emulsion which consists in the main of phenols. The tar contains a resinous substance which is soluble in alkali, and another unidentified substance which smells distinctly like caramel. The aim of the investigation is to compare the condensates from different woods and to endeavour to develop a system of quantitative analysis so that it may be possible to detect variations in the smoke caused by variations in the kind of wood used as well as variations in the conditions of the burning of the sawdust.

III.—ADVISORY WORK

(United Kingdom Section)

General Utilization

The Section of Utilization has been able to deal with a steadily increasing volume of work during the past year which is indicated by the fact that the inquiries received amounted to some two hundred and forty-seven, of which sixty-nine were directly concerned with Empire timbers or with the result of the Empire Marketing Board's work.

With a view to lessening the clerical work and the time involved in dealing with certain types of inquiries which may be somewhat similar in character, work is in hand to adapt the classification of timbers considered suitable for building and structural purposes, already referred to, as an information leaflet for wide distribution.[1] This also has a direct connexion with the work of the Section in the standardising of specifications, as well as with the work of the Empire Forestry Association in the simplification in naming of timbers from various parts of the Empire, through the work of their Timber Names Committee, on which the Laboratory is represented.[2] The following selection of items is representative of the kind of inquiry coming to the Section during the year :—

The preparation of specifications for timber for use in the construction of ladders, and notes on the various species concerned.

The supervision of test work in connexion with the new Laboratory sawmill for the more rapid conversion of experimental timbers.

Notes for the architectural specifications dealing with the new headquarters for the British Broadcasting Corporation, and the provision of a range of Empire timbers suggested for use.

Arrangements for the service trials of furniture squares and parts, from the small-sized home-grown oak that occurs in considerable quantity throughout Great Britain and is difficult to market. The trials have shown encouragement for the utilization of such oak when properly converted and conditioned.

Utilization of poorer class oak for parquetry flooring.

Timbers for the manufacture of certain types of table-tops for a Manchester firm.

Suggestions for the profitable use of sawdust.

Investigation into the deterioration of Douglas fir floors laid in blocks believed to have been manufactured from the offcut of foreign door factories, and hence placed on the British market at a low figure.

The use of home-grown elm for ecclesiastical furniture.

Timbers for use in the new docks at Grimsby, together with specifications and notes on grading.

Home-grown softwoods for use as floor boards in railway wagon construction.

The disposal of home-grown beech top and branchwood by carbonizing.

Advice on the plant necessary and upon the general scheme for disposal of scrub timber by H.M. Forestry Commission in Northern England.

The market for wood fibre insulating boards in Great Britain.

Notes and technical editing work on articles for the Empire Forestry Journal.

The use of home-grown larch for fencing purposes in the building and development schemes of Public Authorities.

Timbers of Empire origin for the manufacture of packing cases.

The suggestion of suitable timbers for various purposes required by the Director of Ordnance Services, and specifications for these.

Timbers suitable for use in butter and other foodstuff containers where non-tainting properties are an essential feature.

The employment for certain purposes of timbers in the rebuilding of the Bank of England.

Timbers for yacht and ship work.

Treatment of oak to produce the colour of externally weathered timber.

Finishing treatment for maple flooring.

Saws suitable for the conversion of certain woods, and tests with various saws upon timber sent in for trial in this respect.

The suggestion of timbers, whether of home-grown or oversea Empire origin, procurable in commercial quantities, seasoned, and at prices competitive with those being paid at present for timbers of foreign origin, for use in the building of motor vehicles.

Timbers in use by wheelwrights in Great Britain.

Many general inquiries have been received on the subject of suitable timbers for construction purposes, flooring, joinery and like uses in buildings, to be erected mainly under the control of Public Authorities.

[1] Cosgrove, J. R. Empire Timbers from Home and Overseas for Building and Structural Purposes. *Forest Products Research Leaflet, No.* 5. (*In preparation.*)

[2] Trade Names of Empire Timbers. *Empire Forestry Handbook*, 1930. Empire Forestry Association, Grand Buildings, Trafalgar Square, W.C.2.

Seasoning

An increased number of inquiries, mainly from Trade sources, was received during the year for information on seasoning, kilns, apparatus and on the moisture relations of timber. The following visitors spent a considerable portion of their period of study at the Laboratory with the Seasoning Section :—Mr. W. L. Greenhill, Forest Products Research Laboratory, Australia ; Mr. C. E. Ashman, Manager, Government Timber Supply, Uganda ; Mr. A. Hensman, Assistant Conservator, Ceylon ; Major G. Aylmer, Sudan Forest Service ; Mr. W. D. Arnot, P.W.D., Kenya ; Mr. H. A. Woodier, Forestal Land, Timber and Railways Company, Natal ; Mr. C. F. R. Williams, Madras Forest Service ; Mr. H. Barber, Utilization Circle, Burma Forest Service.

Dry Rot and other Questions of Mycology

The amount of advisory work dealt with has increased considerably during the year and a large number of inquiries have been received ; many of these have concerned the identification of dry-rot fungi from buildings. Decay in motor bus bodies has been the subject of several inquiries, and other cases have included decay in glass-house timber, railway sleepers, poles, wooden statues, and so on.

Numerous inquiries concerning the cause and prevention of various discolorations and stains in timber have also been received ; in most cases these have proved to be due to moulds and other fungi, but in some instances growth conditions have been responsible.

Several specimens of decayed timber have been received for diagnosis from the overseas Empire, and the cause of dry rot in building timbers in Ceylon is now under investigation.

Damage by Wood-destroying Insects

The number of inquiries by letter received by the Laboratory during the past year for identification of wood-boring insects, or requesting advice concerning remedial and preventive measures, has amounted to 110. In addition, visitors to the Entomology Section have included members of the timber and timber-using industries who required information on some particular point concerning insect damage to timber. In order to facilitate the answering of advisory inquiries and to provide the required information in a concise and useful form, two leaflets have been prepared dealing with *Lyctus* and the Death-watch beetle respectively.[1, 2] The leaflets give a brief description of the insects, the damage they cause, and methods of prevention and control. A number of inquirers, particularly those interested in *Xestobium*, have asked for an inspection of timbers in a building and for a report giving methods of treatment to be supplied. This type of work has been undertaken and forms one of the duties of the Field Officer attached to the staff of the Entomology Section.

[1] *Lyctus* Beetles and Their Control. *Forest Products Research Leaflet*, No. 3.
[2] The Death-watch Beetle. *Forest Products Research Leaflet*, No. 4.

Representation on Outside Committees

The Laboratory is represented on the following Committees :—

Standing Committee on Empire Forestry :
(*Representative* : Director of Research).

Empire Forestry Association :—

Standard Names for Timbers—Sub-Committee
(*Representative* : Director of Research).

Governing Council
(*Representative* : Director of Research).

Publications Committee
(*Representative* : Officer in Charge, Utilization).

British Engineering Standards Association :—

Building Industry Committee
(*Representative* : Officer in Charge, Utilization).

Revision of Aircraft Timber Specifications
(*Representatives* : Officers in Charge, Seasoning and Timber Mechanics.)

Aircraft Technical Committee AC2 on Timber, Glue and Casein Cement
(*Representatives* : Officers in Charge, Seasoning and Timber Mechanics).

Sub-Committee, Fireproofing of Timbers—
(*Representative* : Scientific Assistant, Timber Mechanics).

Empire Marketing Board :—

Empire Timber Publicity Committee—
(*Representative* : Officer in Charge, Utilization).

Imperial Institute :—

Advisory Committee on Timbers
(*Representative* : Officer in Charge, Utilization).

War Office :—

Inter-departmental Works Committee, Sub-Committee on Building Materials
(*Representative* : Officer in Charge, Utilization).

Standing Committee on Empire Forestry
(*Representative* : Director of Research).

British Wood Preserving Association :—

(*Member of Council* : Director of Research).

Publications Committee (Co-opted)
(*Representative* : Officer in Charge, Wood Preservation).

Technical Committee
(*Representatives* : Officers in Charge, Entomology, Wood Preservation, and Scientific Assistant, Mycology.)

Imperial Conference :—

Forestry Sub-Committee
(*Representative* : Director of Research).

IV.—WORK FOR THE EMPIRE OVERSEA

1. General

Empire Timbers Committee : Programme of Work

Under the auspices of the Empire Timbers Committee, a full programme of investigations into Empire timbers has now been developed. The commitments to date in testing work, under the classification explained in last year's report, are : Class (*a*) i, preliminary tests, 13 ; class (*a*) ii, large scale (major) tests, 4 probable ; class (*a*) iii, specialised tests, 4 ; class (*b*) ii, investigations in co-operation with other Empire Forest Products Laboratories, 2 ; commercial trials, 2. In addition, a large amount of advisory work has been carried out, and demands are fast increasing. A detailed account of progress is given in succeeding sections of this report.

Collection of Information

It is the endeavour of the Committee to assemble information concerning the circumstances ruling in the different parts of the Empire, that affect the exploitation of the forests and bear on the problem of successful competition with foreign countries. In the first place, such information is necessary in order to decide which applications for investigations shall be accepted and the order of priority to be given to them. In the

second place, a general picture of this kind should be of great assistance in co-ordinating the three factors, production, research and marketing, so that a joint effort toward efficient exploitation may be made. Such a picture should serve to show the difficulties that exist over the whole field and the way to their removal.

Co-operation with the Imperial Forestry Institute

As foreshadowed in our last report, the removal of the Laboratory's Section of Wood Structure (formerly designated Wood Technology) from Oxford to Princes Risborough took place shortly before the end of the year under review. The close association of our staff with that of the Imperial Forestry Institute during the last five years has made possible a degree of mutual co-operation which has been of benefit to the work of both Institutions.

In order to continue this liaison, and to assist the work of the Institute in so far as it relates to research in forest products, the Department is continuing to pay an annual grant to the Institute for the maintenance of two research workers (with the necessary laboratory assistance and equipment), who are engaged on a programme of work connected with Empire Timbers approved by the Director of Forest Products Research and the Director of the Imperial Forestry Institute. During 1930 this investigation has followed two main lines, namely, the study of anatomical variation in diffuse-porous hardwoods, and detailedd escriptions of the wood anatomy of a number of tropical African species. The latter are intended for publication in a series of complete botanical descriptions of important timber trees, which are being prepared by the Institute.

Collection of Empire Timbers

Following the extension of the Laboratory's functions to include investigations on timbers produced in the Empire overseas, an increasing number of applications has been received by the Empire Timbers Committee. In the case of new timbers about which little or nothing is known, it is desirable that wood specimens should be available for preliminary examination, so that some indication of the quality may be obtained, and in this connexion the need for maintaining a fully representative reference collection is obvious. With the provision of adequate accommodation for the Section of Wood Structure, it has been possible to make a start on the long deferred task of classifying and arranging the Laboratory's collection of wood specimens. It will be appropriate here to refer to the generous action of the Director of the Imperial Institute in presenting to the Laboratory the large collection of timber specimens which from time to time have been sent to the Imperial Institute from all parts of the Empire. The collection, comprising nearly one thousand specimens, was handed over to the Laboratory on the understanding that a representative specimen of each should be prepared and returned to the Imperial Institute for reference. The conversion of the material to suitable sizes, ranging from specimen planks down to small hand specimens, has been nearly completed ; the large size of many of the original specimens will allow of several duplicate sets of hand specimens being prepared for distribution to other Institutions interested in Empire timbers.

A considerable quantity of timber specimens which have been acquired from various sources since the inception of the Laboratory has yet to be converted into hand specimens and incorporated in the collection, and some months must elapse before these arrears can be made up. At the same time, sets of specimens of home-grown timbers are in course of preparation, for exchange with various institutions abroad, many of which have already presented collections of foreign timbers to the Laboratory.

Presentation Sets of Empire Timbers

Following upon the interest aroused through a presentation made last year by the Empire Marketing Board of a set of some fifty Empire timber specimens to the Architectural Association in London for reference purposes, several applications reached the Board for further sets of these timbers. The Laboratory was again entrusted, on behalf of the Board, with the work of collecting, identifying and preparing the timbers for the following Architectural Schools :—

The University of London,
The University of Liverpool,
The University of Manchester,
The University of South Wales,
The Royal Technical College, Glasgow,
The City of Leeds College of Art.

These collections of authenticated specimens have already been of material assistance.

2. Programme of Work

(Oversea Empire Division)

Testing of Empire Timbers

The following timbers have been accepted for general preliminary tests :—

1. East African camphor .. *Ocotea usambarensis* Engl.
   Kenya Colony.
2. African Walnut .. .. *Lovoa Klaineana* Pierre ex Sprague
   Nigeria.
3. Sapeli mahogany .. .. *Entandrophragma septentrionale* A. Chev.
   Nigeria.
4. Sapeli mahogany .. .. *E. cylindricum* Sprague
   Nigeria.
5. Sapeli mahogany .. .. *E. Candollei* Harms.
   Nigeria.
6. Crabwood .. .. .. *Carapa guianensis* Aubl.
   British Guiana.
7. Greenheart .. .. .. *Ocotea Rodioei* Mez.
   British Guiana.
8. Purpleheart .. .. .. *Peltogyne* spp.
   British Guiana
9. Wallaba .. .. .. *Eperua falcata* Aubl.
   British Guiana.
10. Meranti Tembaga .. .. *Shorea leprosula* Miq.
    Federated Malay States.
11. Keruing .. .. .. *Dipterocarpus cornutus* Dyer
    Federated Malay States.
12. Santa Maria .. .. .. *Calophyllum antillanum* Britt.
    British Honduras
13. M'gongo .. .. .. *Ricinodendron Rautanenii* Schinz.
    Rhodesia.

1. *East African camphor, Kenya Colony.*—Tests on this species were undertaken at the request of the Conservator of Forests, Kenya Colony, who stated that it was an excellent timber which occurred in large quantities and was obtainable in very large sizes. Kiln-seasoning tests, mechanical tests on green timber, and woodworking tests on kiln-dried material have already been completed. Air-seasoning tests are in progress.

The timber seasons reasonably well without splitting, though with some distortion. The process is, however, a slow one. Tests which have been completed indicate that the wood is eminently suitable for cabinet and similar work, and that large scale tests are desirable.

2. *African walnut, Nigeria.*—As an outcome of the revision of existing specifications for walnut and mahogany by the Timber Panel of the Sectional Aircraft Committee of the British Engineering Standards Association, the Department was requested to undertake an investigation to discover suitable Empire timbers for use in air-screws, from sources close to the United Kingdom so that supplies could be obtained as speedily as possible in case of emergency. Although the use of wood in air-screws is likely to continue, at any rate for some time to come, yet the market is a comparatively limited one and, in complying with the British Engineering Standards Association's request, it was decided to select in the first instance three timbers which would be likely to command a good market, or the market for which could be widened, for other purposes. The three timbers selected were African walnut, Sapeli mahogany (a mixture of species under this name) and Crabwood.

On African walnut, kiln-seasoning tests, mechanical tests on the green timber and woodworking tests on kiln-seasoned material have already been completed ; other tests are proceeding as the moisture condition of the material permits. A feature of the timber of this species is the presence of black gum-streaks. It has not yet been definitely determined whether this feature will prove to be a defect as far as the manufacture of air-screws is concerned, but for such purposes as panelling and cabinet work it rather enhances than detracts from the value of the wood. The tests so far concluded indicate that, apart from any value which the species may have in air-screw construction, it is eminently satisfactory as a cabinet wood for all except the highest grades of work, as it machines readily and finishes well.

3. *Sapeli mahogany, Nigeria.*—In connexion with the air-screw tests, three species of Sapeli mahogany are under test, namely, *Entandrophragma septentrionale* A. Chev., *E. Cylindricum* Sprague and *E. Candollei* Harms. It was intended to include in these tests *E. utile*, the best known species, but supplies were not received.

The tests on these three species have not advanced as far as those on African walnut. Mechanical tests on green timber have been completed. Kiln- and air-seasoning, mechanical tests on air-dried material, and woodworking tests on both kiln- and air-seasoned material will follow. Sapeli mahogany is already well established as a cabinet wood on the British market.

4. *Crabwood, British Guiana.*—This was the third timber selected for test in connexion with air-screws. Supplies of this timber have not yet arrived at the Laboratory.

5. *Greenheart, British Guiana.*—Kiln-seasoning tests are in progress.

8. *Purpleheart, British Guiana.*—Supplies of this timber have not yet arrived. Two species are said to exist and, as the necessary herbarium material for botanical identification is difficult to obtain owing to the height of the trees, their crowns surmounting the surrounding forest, some delay in testing may be caused.

9. *Wallaba, British Guiana.*—This timber grows in great quantity in pure stands, and a market for it would be of great value to the Colony. In addition to the tests at Princes Risborough for use as a constructional timber, arrangements are under consideration for its test by another organization as a pulp wood. Supplies for testing have not yet arrived.

10 and 11. *Meranti Tembaga and Keruing, Federated Malay States.*—Mechanical tests of the green timber are in progress. Other tests will follow in their ordinary sequence. These timbers ought to displace some of the Philippine Lauan and Apitong which are being sold in the English markets, if they can be imported at competitive prices.

12. *Santa Maria, British Honduras.*—This is a promising associate of mahogany. Supplies of timber for test have not yet arrived.

13. *M'gongo, Rhodesia.*—Preliminary tests on the timber of this species were carried out at the request of Messrs. Rhodesian Timbers, Ltd., with special reference to the possibility of using it as a substitute for balsa. *Ochroma Lagopus* Sw. M'gongo was found to be somewhat heavier than balsa, but finer in texture. The timber seasoned well, had a thermal conductivity about 40 per cent. higher than balsa, but a lower thermal diffusivity. While, therefore, its insulating properties are inferior to those of balsa, its lower thermal diffusivity might make the timber of value for withstanding fluctuating temperatures. M'gongo absorbed antiseptics readily; water-soluble antiseptics are most likely to prove satisfactory when preservative treatment is necessary. It worked readily on all machine tools except the lathe and the recessing machine.

The results of the preliminary tests indicated that large scale investigations of its use for purposes other than as a substitute for balsa were desirable.

The Imperial Institute Advisory Committee is co-operating in an endeavour to discover further possible uses for this timber.

The following timbers have been accepted for special tests :—

1. Abura .. .. *Mitragyne stipulosa* Kuntze
Nigeria.

2. East African Pencil Cedar .. *Juniperus procera* Hochstr.
Kenya Colony and Tanganyika.

3. Queensland walnut .. .. *Endiandra Palmerstonii* C. T. White
Australia.

4. Tasmanian oak .. .. .. *Eucalyptus obliqua* L'Herit.
E. regnans F. Muell (Mountain ash).
Australia.

1. *Abura, Nigeria.*—The investigations on this timber were undertaken at the request of the Director of Forests, Nigeria, as the result of an inquiry from Lloyd's Register of Shipping, with regard to the reputed acid-resisting properties of the timber. Oil and petrol carrying vessels are subject to excessive corrosion of the steel work due to acids in the oils, and it is with the main object of determining the degree of suitability of abura for lining such vessels to check corrosion that the tests have been carried out. The timber appeared to have distinct possibilities for other purposes, so that general preliminary scale tests have also been included. The tests on the kiln-seasoning properties, mechanical properties of the green timber, and woodworking qualities of the kiln-seasoned material have been completed. Chemical investigations embracing parallel tests on

abura and American Swamp Cypress (*Taxodium distichum* Rich.), the acid-resisting properties of the latter being well established, are proceeding, so that some definite standard of resistance of abura may be established. The tests so far indicate that abura stands up to a 1 per cent. solution of sulphuric acid as well as does Swamp Cypress.

The excellent machining qualities of abura seem to show that it would prove a valuable timber for such machine-made mouldings as are now largely made of Satin walnut (*Liquidambar styraciflua* Linn.) obtained from the United States of America. Larger scale tests appear to be eminently desirable.

2. *East African Pencil cedar, Kenya and Tanganyika.*—Pencils made of the wood of the East African Pencil cedar are said to be harder and "whittle" less readily than those made from the Florida pencil cedar (*Juniperus virginiana* Linn.). Another difficulty is said to be that the pencil slats are very liable to warp during seasoning. At the request of the Conservators of Forests, Kenya and Tanganyika, investigations have been undertaken with the object of discovering methods of overcoming these defects. Chemical investigations for the discovery of a softening treatment are in progress, together with seasoning tests.

3. *Queensland walnut, Australia.*—The appearance and working qualities of this timber are such that its use for panelling and cabinet work might be considerably increased were it not for an objectionable odour which it possesses. Investigations are being planned with the object of discovering a method of removing or minimising this defect. It has been reported that kiln-seasoning the wood results in a temporary eradication of the unpleasant odour but that, if the wood is reworked or heated, the odour returns. Further investigations are in progress in the Chemistry Section.

4. *Tasmanian oak, Australia.*—At the request of the Australian Council for Scientific and Industrial Research, an investigation was undertaken, in co-operation with the Council's Division of Forest Products, to ascertain the possibility of reconditioning or restoring "collapsed" Tasmanian oak. This defect was so general as to threaten the trade in this timber with extinction. This investigation has had very successful results, which are described in detail on page 42. A special letter of thanks has been received by the Department from the Australian Research Council for the assistance afforded in this and other matters, while letters of appreciation have also been received from United Kingdom firms who are users of Tasmanian oak.

The following timbers have been accepted for commercial trials :—

1. Silver beech .. .. *Nothofagus Menziesii* Oerst.
   Tawa *Beilschmedia tawa* T. Kirk
   New Zealand.
2. Indian-grown Honduras mahogany *Swietenia macrophylla* King.
   India.

1. *Silver beech and tawa, New Zealand.*—The Silver beech has arrived and arrangements have been made to test this species as a furniture wood in High Wycombe. Sections of flooring of Silver beech in block and strip forms have been laid in the corridors at the Laboratory, where it will be possible to compare its resistance to wear with that of a number of other species. The timber is also to be tested as to its suitability for rifle-stocks at the Small Arms Factory, Enfield. Tests in other directions are contemplated. The tawa has not yet arrived.

2. *Indian-grown Honduras mahogany, India.*—The Indian Government is desirous of determining whether Indian-grown Honduras mahogany possesses qualities which

are at all comparable with those of the Honduras-grown timber. It is proposed to submit Indian-grown material to commercial tests to determine how far and for what purposes it may safely be substituted for native British Honduras mahogany. The timber has not yet arrived.

Practical Trials of Empire Flooring and Decorative Timbers in the Laboratory Buildings

Flooring in both block and strip form of the following Empire timbers has been laid in the corridors of the Laboratory :—

Tasmanian oak ..	*Eucalyptus obliqua* L'Herit.
Jarrah	*E. marginata* Sm.
Tallow wood	*E. microcorys* F. Muell.
Blackbutt	*E. pilularis* Sm.
Canadian birch ..	*Betula lutea* Michx.
Canadian maple ..	*Acer saccharum* Marsh.
Canadian Douglas fir ..	*Pseudotsuga taxifolia* Brit.
Home-grown Douglas fir	,, ,, ,,
New Zealand beech ..	*Nothofagus* spp. (including *N. Menziesii* Oerst. and *N. fusca* Oerst.).
Gurjun	*Dipterocarpus* spp. (including *D. alatus* Roxb., *D. costatus* Gaertn. f., *D. Griffithii* Miq. and *D. turbinatus* Gaertn. f.).
Borneo camphor wood (Mahoborn teak).	*Dryobalanops aromatica* Gaertn. f.
Home-grown Scots pine	*Pinus sylvestris* L.

Imported Red deal (*Pinus sylvestris* L.) has also been used in both block and strip form, as a well-known flooring wood to provide the basis for comparison.

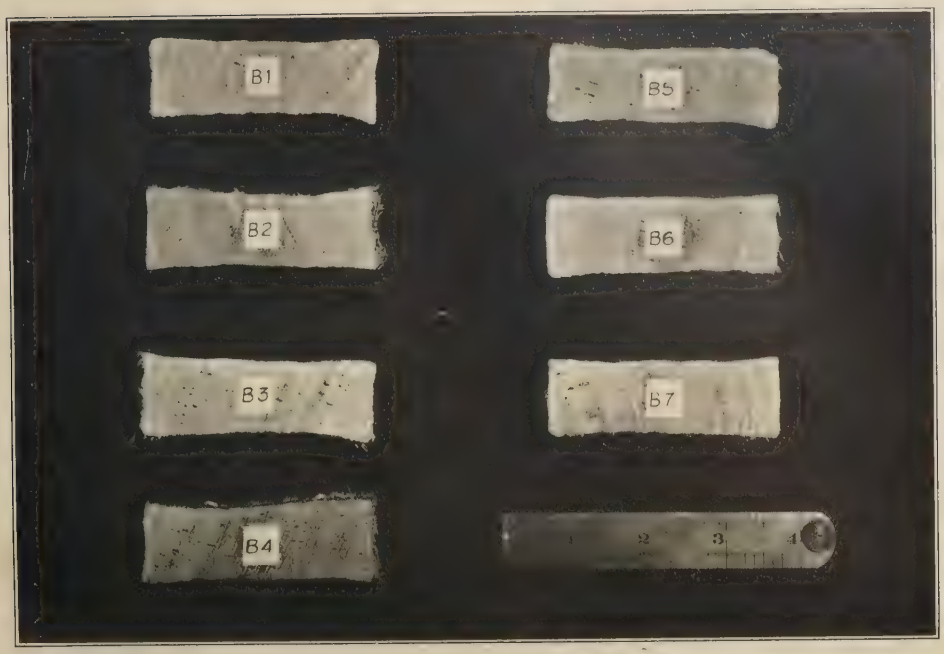
In order that the ornamental and decorative qualities of a number of Empire timbers may be better appreciated it is proposed to panel the new Board Room at the Laboratory, and to use a different timber for each separate panel. By so doing it will be possible to display forty or more species in panel form, some in the solid and others in the form of veneers on a plywood foundation.

Collapse in Timber, with Special Reference to Tasmanian oak: Reconditioning by means of a High Temperature Steaming Treatment

Allied to shrinkage in its results, there occurs during the seasoning of certain timbers a defect known as "collapse," caused by the collapse or caving in of the cells of their structure. Sometimes its external effects are scarcely obvious and to all appearance are no more than a somewhat excessive shrinkage of the wood ; but often collapse can be very easily detected from an irregular reduction of the cross-section of the material, examples of which are shown in Fig. 10(A). Certain species are notably prone to collapse and it may be that more timbers than is suspected are susceptible to it in a greater or lesser degree.

Experiments have been made during the year to ascertain the possibility of reconditioning or restoring collapsed Tasmanian oak (*Eucalyptus obliqua* and (or) *E. regnans*). This timber is an excellent flooring timber, but is liable to collapse to a varying extent during seasoning.

The treatment in detail was suggested by Mr. I. H. Boas, Chief of the Division of Forest Products, Australian Commonwealth Council for Scientific and Industrial Research,



(*A*) Before Treatment.

(*B*) After Treatment.

FIG. 10.—*Reconditioning of Collapsed Tasmanian Oak.*

(*A*) Photomicrograph (× 30) of the end surface of a piece of collapsed Tasmanian oak.

(*B*) Photomicrograph (× 30) of the same piece of wood after reconditioning.

FIG. 11.—*Collapsed and Reconditioned Tasmanian Oak.*

and his Officer in charge of Seasoning, Mr. Stanley A. Clarke, as one known to have been successfully used in Australia. It consisted of warming the dried timber to 210° F. in saturated air, and maintaining the conditions for four hours (for timber 1 inch in thickness) before opening the doors of the chamber and allowing the timber to cool.

In the actual experiment made, a load of 3-inch by 1-inch Tasmanian oak flooring, supplied by a firm of importers in Great Britain, was first kiln-dried to below 15 per cent. moisture content and allowed to cool in the drying chamber, this being stated by the Australian Laboratory as necessary to the subsequent reconditioning treatment. The doors of the chamber were then closed and the special treatment started. In six hours the necessary conditions were reached and, after these had been maintained for the specified four hours, the kiln doors were opened and the material allowed to cool quickly. A second experiment in which the four hours' period was increased to six hours showed slightly better results; both this and subsequent tests showed the latter period to be the limiting time which would be economically justified for 1-inch material.

The results of the reconditioning treatment were good to a quite unexpected extent. The restoration of the timber may be seen from the accompanying photographs of Fig. 10, showing the cross-sections of defective boards before and after treatment. The improvement in the individual pieces was naturally reflected in the appearance of the material in bulk, which was transformed from a pile of ill-assorted and misshapen pieces into one of average quality. Other features of the treatment may be mentioned. The gain in moisture content was small and about ½ per cent. The timber was flat-piled and bent pieces were considerably flatter after the treatment, though only a small improvement resulted in those curved in their own plane. The timber checked a little on its edges, but to a commercially insignificant extent.

Tests of the mechanical properties of the timber before and after reconditioning showed the absence of any injurious effect and indicated that the fibre strength had not been impaired, for, though there was on the average a slight reduction in the strength per square inch in the treated material, this corresponded almost exactly with the increase in the cross-sectional areas. A test of the machining qualities of a few pieces indicated that the reconditioned material was milder and worked more easily and better. This was confirmed when the timber was manufactured into flooring in bulk, the machinists holding the opinion that there was a slight but definite improvement in the material, which machined well and with a rather better finish than is customary with unsteamed stock. In cutting a groove, better results came from the reconditioned Tasmanian oak, the grain of which did not tend to lift.

It is an obvious question to ask if the timber will recollapse. In answer it can be said that, under normal conditions in use, there appears to be no reason why it should, and subsidiary experiments which are still in progress appear to indicate that the collapse is not a natural state of the timber, but one which tends to disappear as soon as suitable conditions prevail. A more convincing reply, however, is the fact that timber kept under observation in Australia for six years after reconditioning has shown no sign of a recurrence of its earlier defect.

It should be mentioned that so far as concerns Tasmanian oak itself, the experiments on reconditioning have less value in this country from the fact that the shippers of the timber are already taking steps to carry out the treatment before export. Their value will still remain, however, in the possibility of the treatment of other timbers which are prone to collapse, in which class some of the home-grown elms may certainly be included, and in cases where reconditioned timber has been allowed to become very wet again during shipment.

A microscopic examination of collapsed Tasmanian oak before and after the reconditioning treatment was carried out by the Section of Wood Structure. The condition of the wood before and after treatment is illustrated in Fig. 11. A photomicrograph of the end surface of a collapsed piece of Tasmanian oak is shown in (A). The distortion of the wood, due to the caving in of the cell walls, is most obvious in the case of the large pores or vessels. A photomicrograph of exactly the same piece of wood after it has been restored to its normal dimensions by a reconditioning treatment is shown in (B). Comparison of the two photographs shows the alteration in the size and shape of the individual pores and the striking change in the overall dimensions of the section.

Creosoting of British Columbia Douglas Fir Railway Sleepers

Douglas fir (*Pseudotsuga taxifolia* Brit.) is a timber which, compared with most other softwoods, is difficult to impregnate with preservatives. In recent years it has been very largely imported from British Columbia for railway sleepers and when creosoted by the usual methods adopted for Baltic fir it has been found difficult to inject the specified amount of 9 to 10 lb. of creosote per cubic foot, the usual absorption being less than half this amount. Results have shown that Douglas fir treated in this ineffective manner has had an average life varying from 8 to 10 years only, instead of the 20 years or so usually obtained from a creosoted Baltic sleeper. This short life is due to the small amount of creosote absorbed and the very small depth of impregnation obtained. It has been found that for satisfactory service the creosote must penetrate the sleeper to such a depth that any subsequent abrasions or natural splitting of the surface will not expose untreated wood to attack by fungus.

In Canada and the United States of America a satisfactory method has been found for creosoting Douglas fir and has been in customary use for a number of years. Apart from appropriate specifications for the vacuum and pressure periods, and temperature, the treatment includes a process known as "incising," in which the sleepers are placed under a roller equipped with staggered rows of knives producing a close series of incisions about ¾-inch deep and 1 inch long over the sleepers. In order to demonstrate the efficacy of this treatment to users in this country the Laboratory is carrying out an investigation, a report upon the results of the first stages of which has just been circulated to the various interests concerned. These results confirm the experience of Canada and the United States that a satisfactory impregnation of creosote can be obtained with Douglas fir sleepers. They also indicate that, to do this, it is essential that the sleepers should be incised before treatment for the following reasons :—

(i) To obtain a uniform depth of impregnation on all sides of the sleeper.
(ii) To shorten the time of treatment necessary to obtain a specified absorption.
(iii) By shortening the time of treatment, to avoid excessive end penetration and at the same time ensure sufficient lateral penetration.

The results show that uniformity of penetration is by far the greatest advantage obtained from incising. Apart from incising, the main factors to be considered in the treatment of British Columbia Douglas fir sleepers are the temperature of the oil, the duration of the pressure period, and the degree of seasoning of the timber. The following suggestions are made :—

1. The treatment should consist of a high preliminary vacuum of 20 inches for 1 hour, followed by a pressure period of 170–180 lb. per square inch until an absorption of 10 lb. per cubic foot has been obtained. This should usually be from 3 to 5 hours. The temperature of the creosote should not be below 160° F. nor higher than 200° F. during time of treatment.

2. Particular attention should be paid to the seasoning of the sleepers so that they should be in as dry a condition as possible immediately prior to impregnation.

The report of the above investigation has been circulated to public authorities, railways, creosoting firms, and others interested in the use of creosoted Douglas fir. At the instance of the Empire Timbers Committee, following the proposal of Mr. Harrison Watson, the Chief Canadian Government Trade Commissioner in the United Kingdom, a covering letter was issued with the report urging the great importance of creosoting this timber by appropriate methods, in the following terms :—

> " . . . . at a recent meeting of the Empire Timbers Committee, the Committee had before them the question of the creosoting of British Columbia Douglas fir. They are aware that in the past the general opinion has been that no more than 3½ lb. of creosote to the cubic foot can be injected into this timber, an amount which practical experience has shown to be entirely inadequate for preserving the timber. To ensure adequate preservation an injection of 8 to 10 lb. to the cubic foot is necessary. In Canada and America it has been found possible, by improved technique, to inject 10 lb. and over of creosote into the timber. Investigations at this Laboratory have confirmed this possibility.
>
> " The Committee view the partial treatment (3½ lb. per cubic foot) of Douglas fir with grave concern, in view of the increasing use of the timber in the United Kingdom. Both in the interests of the user in this country and for the sake of the reputation of this valuable Empire timber, the Committee desire me to urge upon you the great importance of employing methods of treatment which will ensure adequate protection to the timber."

From the replies received following circulation of the letter and report, it is evident that action in this matter has gone a long way towards producing the desired result.

Empire Plywoods

As an outcome of an inquiry from the Cambridgeshire Education Committee to the Empire Marketing Board concerning plywood manufactured from Empire timbers, a meeting was arranged at the offices of the Board on Tuesday, 11th November, 1930. Representatives of the British plywood manufacturers, and the large plywood consumers, including H.M. Office of Works and the London County Council, were present.

The object was to gather from the meeting whether there were any means whereby the Empire Marketing Board could further the marketing of Empire plywood either by research through the Forest Products Research Laboratory or by other means. As a result of the discussion it was evident that sales in certain classes of British plywood, especially such as were used for high-class ornamental work or for aeroplanes, were increasing, but that British manufacturers found it very difficult or impossible to compete in the market for the cheapest grades. Consumers and manufacturers were getting together, however, with the result that a greater proportion of plywood produced within the Empire was being consumed.

Co-operation with other Empire Laboratories

The collaboration of the previous year with the Vancouver Branch of the Forest Products Research Laboratories of Canada, with the view to determining the moisture and other changes in timber during transport from Western Canada to this country, is being continued.

A further example of useful co-operation is the work on the reconditioning of Tasmanian oak, already described in detail (p. 42), which was carried out at the request of the Forest Products Division of the Australian Commonwealth Council for Scientific and Industrial Research.

The Director and his staff are in constant touch by correspondence with the other Laboratories of the Empire on a variety of matters arising during the course of the work.

Advisory Work (Oversea Empire)

In addition to the interchange of correspondence with the other Laboratories of the Empire, the Forest Services, and with various private firms on matters connected with the programme of research, the following general inquiries were dealt with: India (operating details of charcoal kilns, mahogany markets and uses, sleepers); British Honduras (woods for battery separators); Canada (flotation of hardwood logs, special uses, markets, carbonization, timbers for harbour works, flooring timbers); New Zealand (timbers for flooring, rifle-stock woods, air-screws, box and case-making woods); Australia (woods for handles, timbers for presentation, caskage woods); Burma (marine timbers, handle woods, markets); Gold Coast (markets, and general development in use of timbers); British Guiana (equipment for logging and extraction of timber, markets, uses); East African Dependencies (uses and markets, utilization of bark, woodworking tests).

The heaviest amount of advisory work was that resulting directly or indirectly from the activities of the Empire Marketing Board. Of the 69 major inquiries under this head, 48 dealt with the use of Empire timbers (including home-grown) in building construction, joinery and flooring, principally in connexion with new building work. It is of additional interest that 38 of these 48 inquiries came from county, borough, municipal or educational authorities. The remainder came from architects and commercial firms from widely separated parts of the Kingdom.

Courses of Study for Research and Utilization Officers

During the period under review, twelve more officers have attended the Laboratory for courses of study, namely:—

Forest Services: India, 3; Burma, 1; Ceylon, 1; Nigeria, 1; Sudan, 1; Cyprus, 1; Australia, 1.

Other Departments: Indian Ordnance, 1; Government Timber Supply, Uganda, 1; Commercial, South Africa, 1.

The total number of officers who have taken these courses is now twenty-three.

R. S. PEARSON,
Director.

April, 1931.

APPENDIX I

LIST OF SCIENTIFIC AND TECHNICAL STAFF

Director of Forest Products Research : R. S. Pearson, C.I.E., F.L.S.
Assistant Director : F. M. Oliphant.
Assistant : H. A. Cox, M.A.
Administration Officer : A. R. H. Cox.
Scientific Field Assistant : A. N. David.
Publications and Records Officer : W. H. Lovegrove.
Technical Assistant (Photographer) : W. R. Hutchins.

Section of Wood Structure

Officer in Charge : B. J. Rendle, B.Sc., A.R.C.S.
Junior Assistants : S. H. Clarke, B.Sc. ; E. W. J. Phillips, B.Sc., A.R.C.S.

Section of Timber Physics

Officer in Charge : W. W. Barkas, M.Sc.
Assistant, Second Class : E. D. van Rest, B.Sc.

Section of Seasoning

Officer in Charge : S. T. C. Stillwell, B.Sc.
Assistant, Second Class : R. G. Bateson, B.A.
Junior Assistants : R. A. G. Knight, B.Sc. (Eng.) ; W. C. Stevens, M.A.
Junior Technical Assistants : L. S. Doman ; R. E. Hodge ; G. H. Pratt ; D. D. Johnston ; R. J. Newall ; N. Turner.

Section of Timber Mechanics

Officer in Charge : C. J. Chaplin, M.Sc., M.E.I.C.
Assistant, First Class : F. M. Mooney, B.Sc., A.M.E.I.C.
Assistants, Second Class : F. H. Armstrong, M.Sc., A.M.I.Mech.E. ; J. Latham, B.Sc. ; Miss C. B. Pettifor, B.Sc.
Junior Assistants : T. Hamilton, B.Sc. ; E. H. Nevard, B.Sc.
Technical Assistant : Miss I. M. Elliott, B.Sc.
Junior Technical Assistant : A. J. Foord.

Section of Wood Preservation

Officer in Charge : J. Bryan, M.Eng., A.M.Inst.C.E.
Junior Assistant : N. A. Richardson, B.Sc.
Junior Technical Assistant : D. N. Smith.

Section of Mycology

Officer in Charge : K. St. B. Cartwright, B.A., B.Sc.
Assistant, Second Class : W. P. K. Findlay, B.Sc., A.R.C.S.
Junior Technical Assistant : E. C. Badcock.

Section of Entomology

Officer in Charge : R. C. Fisher, Ph.D., B.Sc.
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Junior Technical Assistant : E. C. Harris.

Section of Wood Chemistry

Officer in Charge : W. G. Campbell, B.Sc., M.S.
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Junior Assistants : J. Booth, Ph.D., B.Sc., A.I.C. ; Miss K. F. Taylor, Ph.D., B.Sc.

Section of Utilization

Officer in Charge : J. R. Cosgrove, D.S.O., M.C., M.E.I.C.
Assistant, Second Class : P. Harris, B.Sc.
Junior Assistant : J. A. Buchanan, B.A.
Senior Technical Assistant : J. C. Thirlwell.
Technical Assistant : Miss D. M. Wells, B.Sc.

APPENDIX II

LIST OF PUBLICATIONS

A.—*Stationery Office Publications**

	Price s.	d.
Report of the Forest Products Research Board for the period ended 30th September, 1928 .. .. (1929)	3	0
Report of the Forest Products Research Board for the period ended 31st December, 1929 (1930)	4	0

TECHNICAL PAPERS :—

No. 1.—The Movement of Moisture with reference to Timber Seasoning. By S. T. C. Stillwell, B.Sc. .. .. (*Out of print*)		
No. 2.—Moisture Movement through Wood. The Steady State. By J. F. Martley, D.I.C., B.Sc. .. .. (1926)	1	3

SPECIAL REPORTS :—

No. 1.—The Air-Seasoning and Conditioning of Timber. By F. M. Oliphant (1927)	2	0
No. 2.—The Principles of Kiln-Seasoning of Timber. Part I.—Types of Commercial Kilns in Use. By S. T. C. Stillwell, B.Sc. .. .. (1928)	0	9

BULLETINS :—

No. 1.—Dry Rot in Wood .. .. (1928)	1	6
No. 2.—*Lyctus* Powder-Post Beetles. By Ronald C. Fisher, B.Sc., Ph.D. .. (1929)	3	0
No. 3.—British Hardwoods. Their Structure and Identification. By L. Chalk, M.A., and B. J. Rendle, B.Sc. .. .. (1929)	5	0
No. 4.—Decay of Sitka Spruce Timber caused by *Trametes serialis* Fr. By K. St. G. Cartwright, B.A. .. .. (1930)	2	0
No. 5.—The Moisture Content of Wood with reference to Furniture Manufacture. By S. T. C. Stillwell, B.Sc. .. .. (1930)	2	0
No. 6.—The Timber of Corsican Pine (*Pinus Laricio* Poiret) .. .. .. (1930)	2	6
No. 7.—Home-Grown Timbers. Their Anatomical Structure and its Relation to Physical Properties. Elm. By S. H. Clarke, B.Sc. .. .. .. (1930)	3	6
No. 8.—The Use of Home-Grown Larch Poles for Transmission Lines .. .. (1931)	2	0
No. 9.—Home-Grown Pitprops .. .. (1931)	2	0
No. 10.—The Timber of Home-Grown Douglas Fir .. .. (1931)	3	0
No. 11.—The Effect of Progressive Decay on the Mechanical Strength of the Wood of Sitka Spruce by *Trametes serialis* Fr. By K. St. G. Cartwright, B.A., D.I.C., W. P. K. Findlay, B.Sc., D.I.C., C. J. Chaplin, M.Sc., M.E.I.C., and W. G. Campbell, B.Sc., M.S. .. .. (1931)	1	6

* *Obtainable from any of the Sale Offices of His Majesty's Stationery Office, LONDON : Adastral House, Kingsway, W.C.2 ; EDINBURGH : 120, George Street ; MANCHESTER : York Street ; CARDIFF : 1, St. Andrew's Crescent ; BELFAST : 15, Donegall Square West.*

PROJECTS :—

	Price s.	d.
Project 1.—Mechanical and Physical Properties of Timber. Tests of Small Clear Specimens. By C. J. Chaplin, M.Sc., M.E.I.C. .. .. .. (1928)	2	0
Project 1. Progress Report 1. Test of some Home-Grown Timbers in their Green Condition. By C. J. Chaplin, M.Sc., M.E.I.C. .. .. .. (1928)	0	9
Project 1.—Progress Report 2. Tests of some Home-Grown Timbers in their Green and Seasoned Conditions. By C. J. Chaplin, M.Sc., M.E.I.C., and F. M. Mooney, B.Sc., A.M.E.I.C. .. .. (1929)	1	0

MISCELLANEOUS :—

The Uses of Home-Grown Timber. *Compiled by a Committee comprising representatives of the Land Agents' Society, The Federated Home-Grown Timber Merchants' Association, The Royal Institute of British Architects and the Forest Products Research Laboratory* .. .. *Revised edition* (1929)	1	0

The following leaflets may be obtained, gratis, only from the Director, Forest Products Research Laboratory, Princes Risborough, Bucks.

LEAFLETS :—

No. 1.—" Worm " in Furniture.* By Ronald C. Fisher, B.Sc., Ph.D. .. .. (1927)
No. 2.—The Influence of Certain Factors on the Kiln-Drying of Timber and on the Choice of the Types of Drying Kiln. By S. T. C. Stillwell, B.Sc. .. (1928)
No. 3.—*Lyctus* Beetles and Their Control .. .. (1930)
No. 4.—The Death-Watch Beetle .. .. (1931)
No. 5.—Empire Timbers from Home and Overseas for Building and Structural Purposes. By Major J. R. Cosgrove, D.S.O., M.C., M.E.I.C. .. .. (1931)

B.—*Other Publications*

BRYAN, J.

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The Open Tank Process for Antiseptic Treatment of Timber for Estates, Farms, Collieries, etc. *Journal of the Bath and West and Southern Counties Society*. Sixth Series, **5**, 1930–1931.

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CARTWRIGHT, K. St. G. and FINDLAY, W. P. K.

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* Out of stock. Revised edition under consideration.

B.—*Other Publications*—continued.

CHAPLIN, C. J.

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The Use of the Projection Apparatus in Anatomical Studies of Timbers. *Forestry*, 1930, **4** (1), 40–44.

The Differential Shrinkage of Wood. *Forestry*, 1930, **4** (2), 93–104.

The Tertiary Wall of Wood Fibres. Paper read before the *British Association*, 1930.

COSGROVE, J. R.

Empire Timbers. *Architects' Technical Reference*. (To be published by the *Architectural Association*.) (*In the press.*)

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